US010697148B2

(12) **United States Patent**
Hallale et al.

(10) **Patent No.: US 10,697,148 B2**
(45) **Date of Patent: Jun. 30, 2020**

(54) **HYBRID LOADER BOOM ARM ASSEMBLY**

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(73) Assignee: **Deere & Company**, Moline, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/950,875**

(22) Filed: **Apr. 11, 2018**

(65) **Prior Publication Data**

US 2019/0316316 A1 Oct. 17, 2019

(51) **Int. Cl.**

E02F 3/38	(2006.01)
E02F 3/34	(2006.01)
B29D 99/00	(2010.01)
E02F 9/22	(2006.01)
B32B 1/08	(2006.01)
B32B 27/06	(2006.01)
B32B 27/08	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***E02F 3/382*** (2013.01); ***B29D 99/0003*** (2013.01); ***B32B 1/08*** (2013.01); ***B32B 27/065*** (2013.01); ***B32B 27/08*** (2013.01); ***E02F 3/34*** (2013.01); ***E02F 9/2275*** (2013.01); *B32B 27/308* (2013.01); *B32B 27/38* (2013.01); *B32B 27/40* (2013.01); *B32B 2262/101* (2013.01); *B32B 2262/106* (2013.01)

(58) **Field of Classification Search**

CPC E02F 3/369; E02F 3/34; E02F 3/38; E02F 9/2275; B29D 99/0003; B32B 27/065; B32B 27/08; B32B 27/308; B32B 27/38; B32B 27/40; B32B 2262/101; B32B 2262/106

See application file for complete search history.

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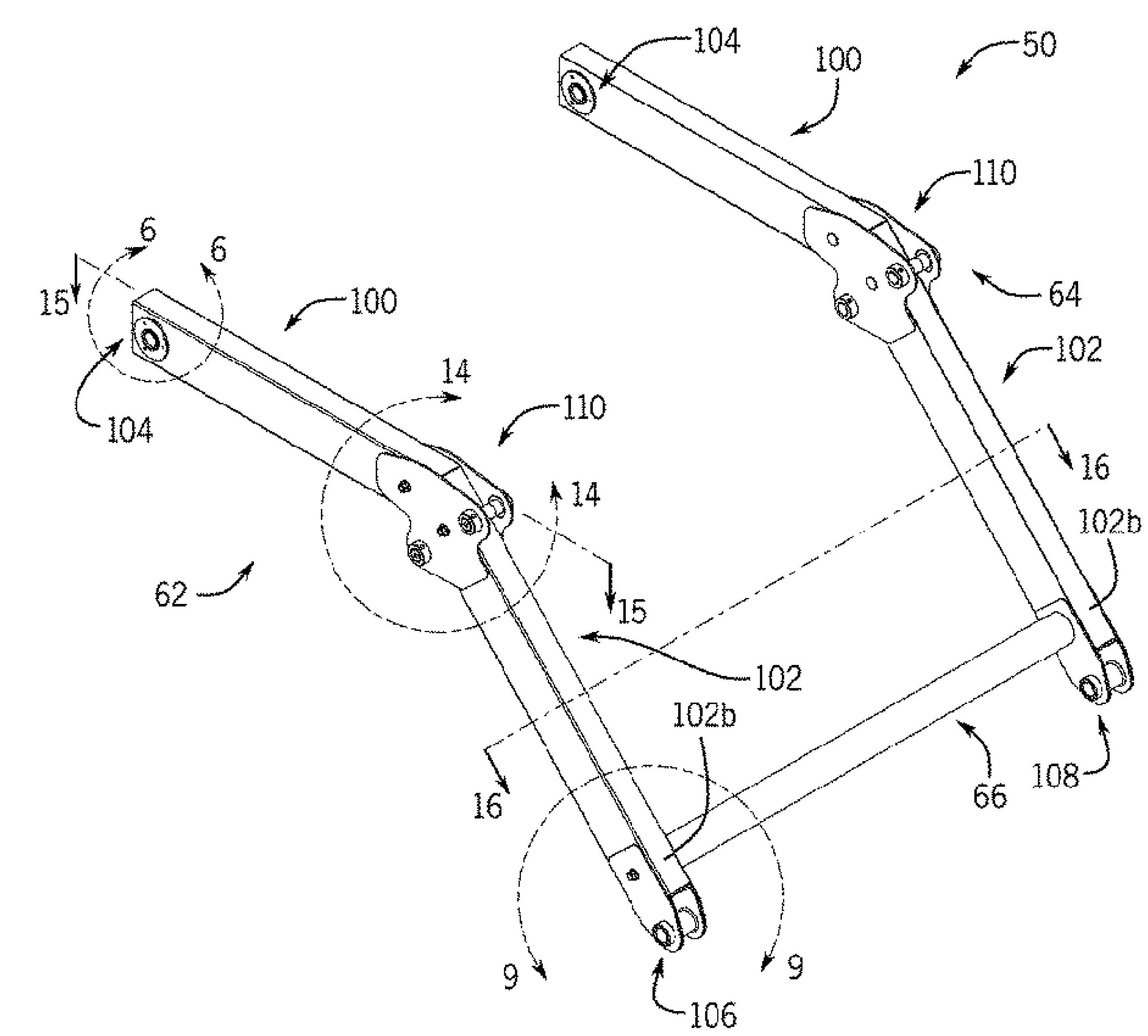
Primary Examiner — Ronald P Jarrett

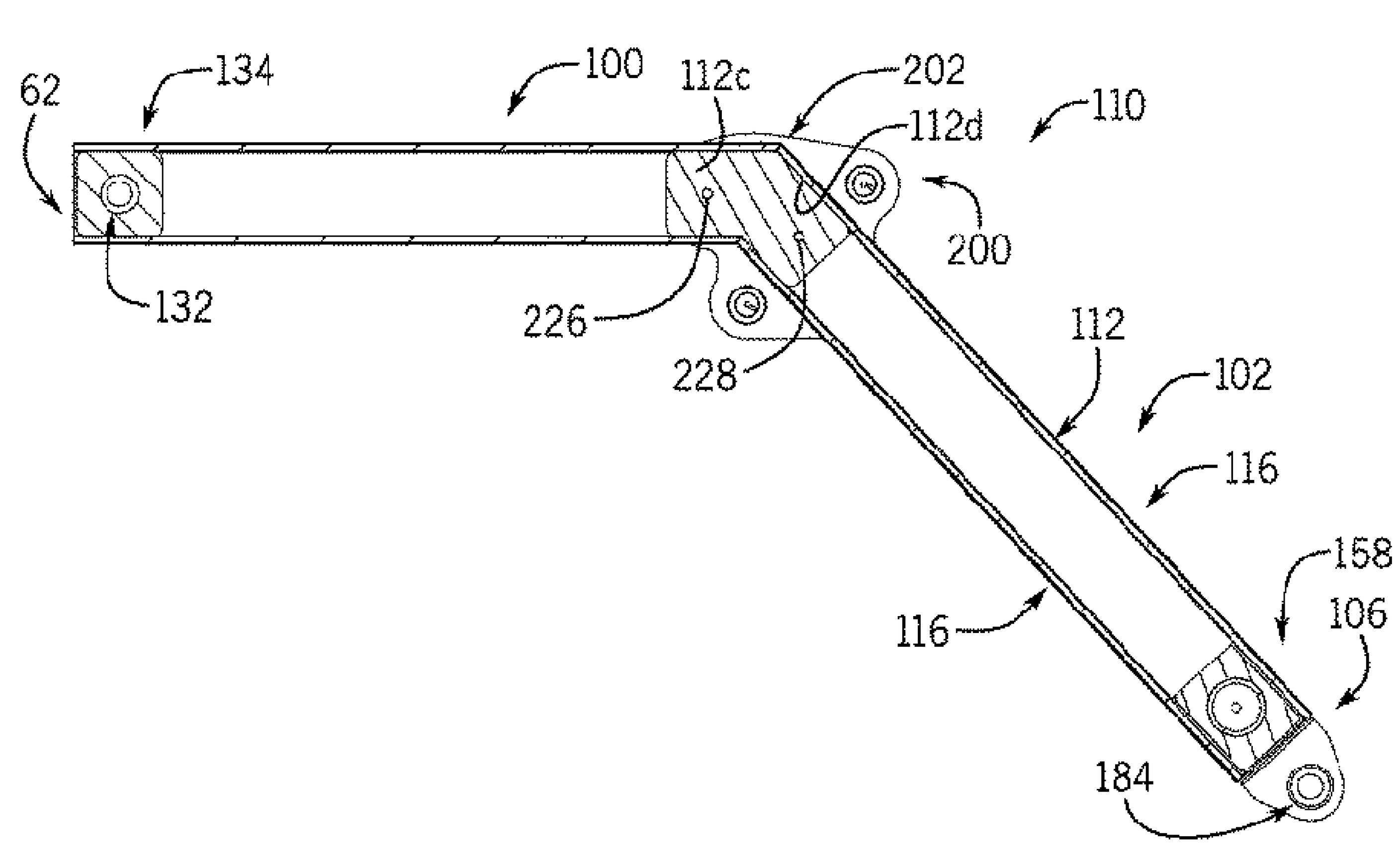
(74) *Attorney, Agent, or Firm* — Tucker Ellis LLP

(57) **ABSTRACT**

A hybrid loader boom arm assembly kit for a loader work vehicle includes a hollow first beam formed from a lightweight material, and a block formed from a second lightweight material. The block is configured to couple within the first beam. The kit includes at least one first steel reinforcing plate configured to couple to the first beam at the end, and at least one connecting plate configured to couple to the at least one first reinforcing plate.

20 Claims, 29 Drawing Sheets





(51) **Int. Cl.**

B32B 27/30	(2006.01)
B32B 27/38	(2006.01)
B32B 27/40	(2006.01)

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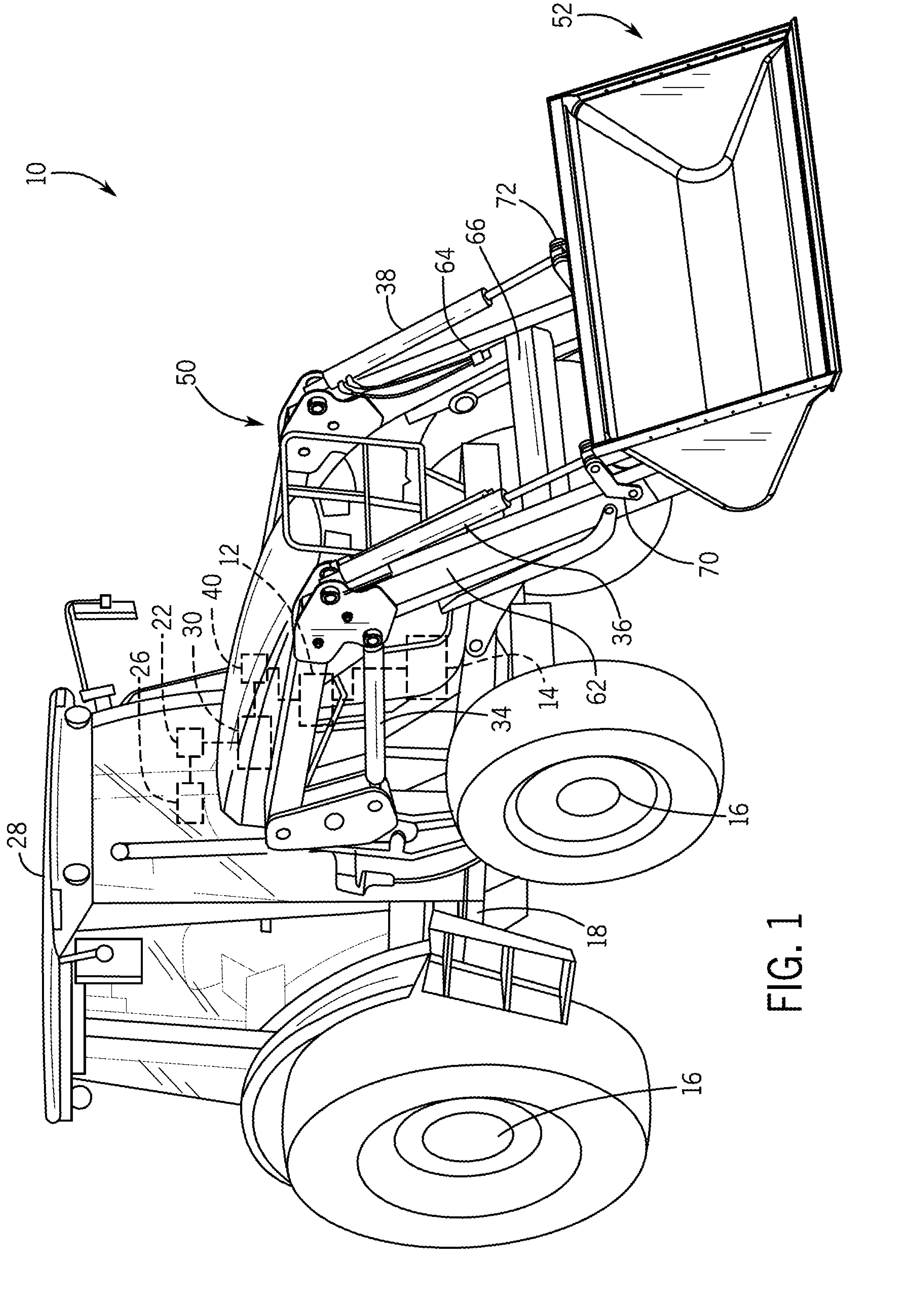
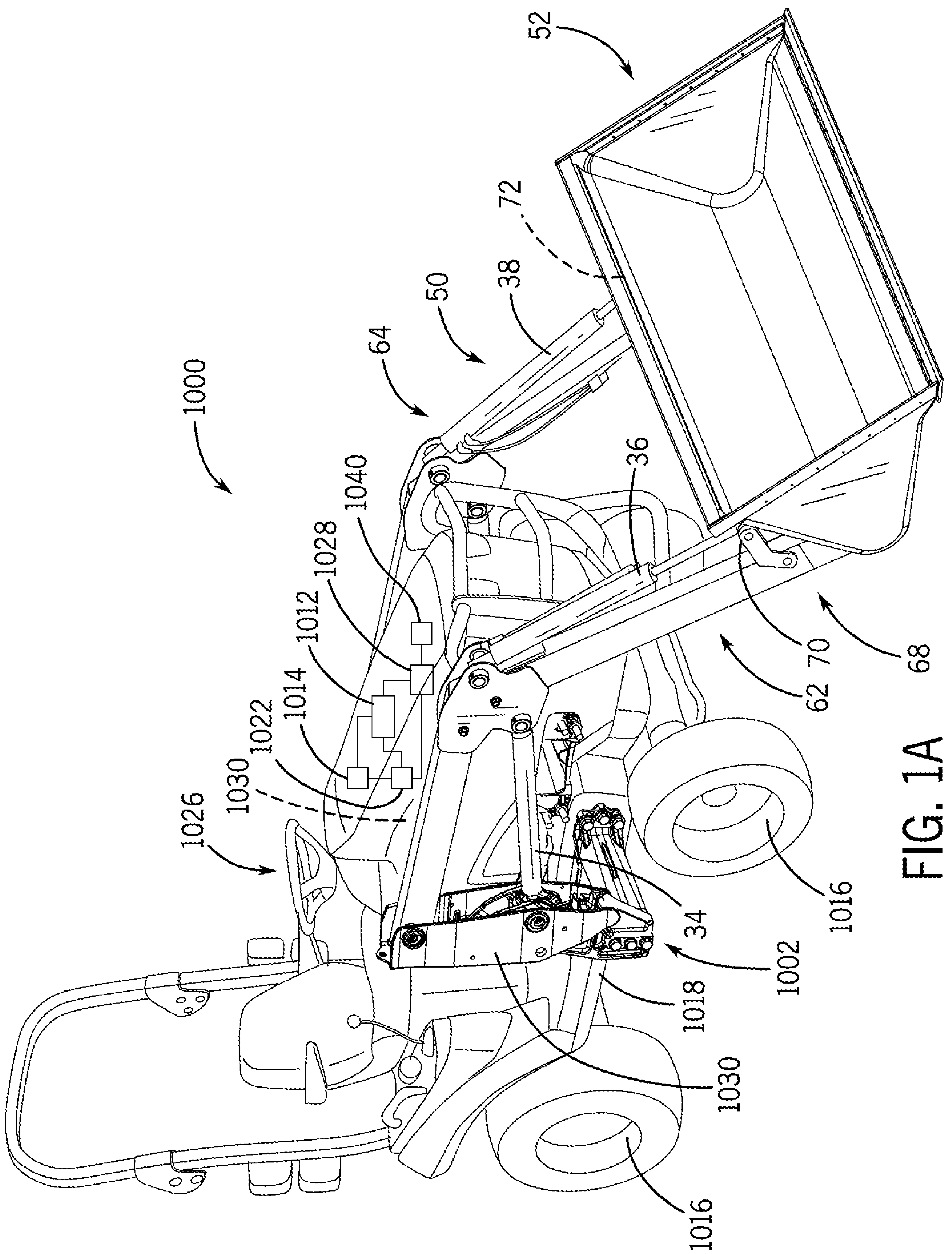


FIG. 1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1018
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1016
1016

FIG. 1A

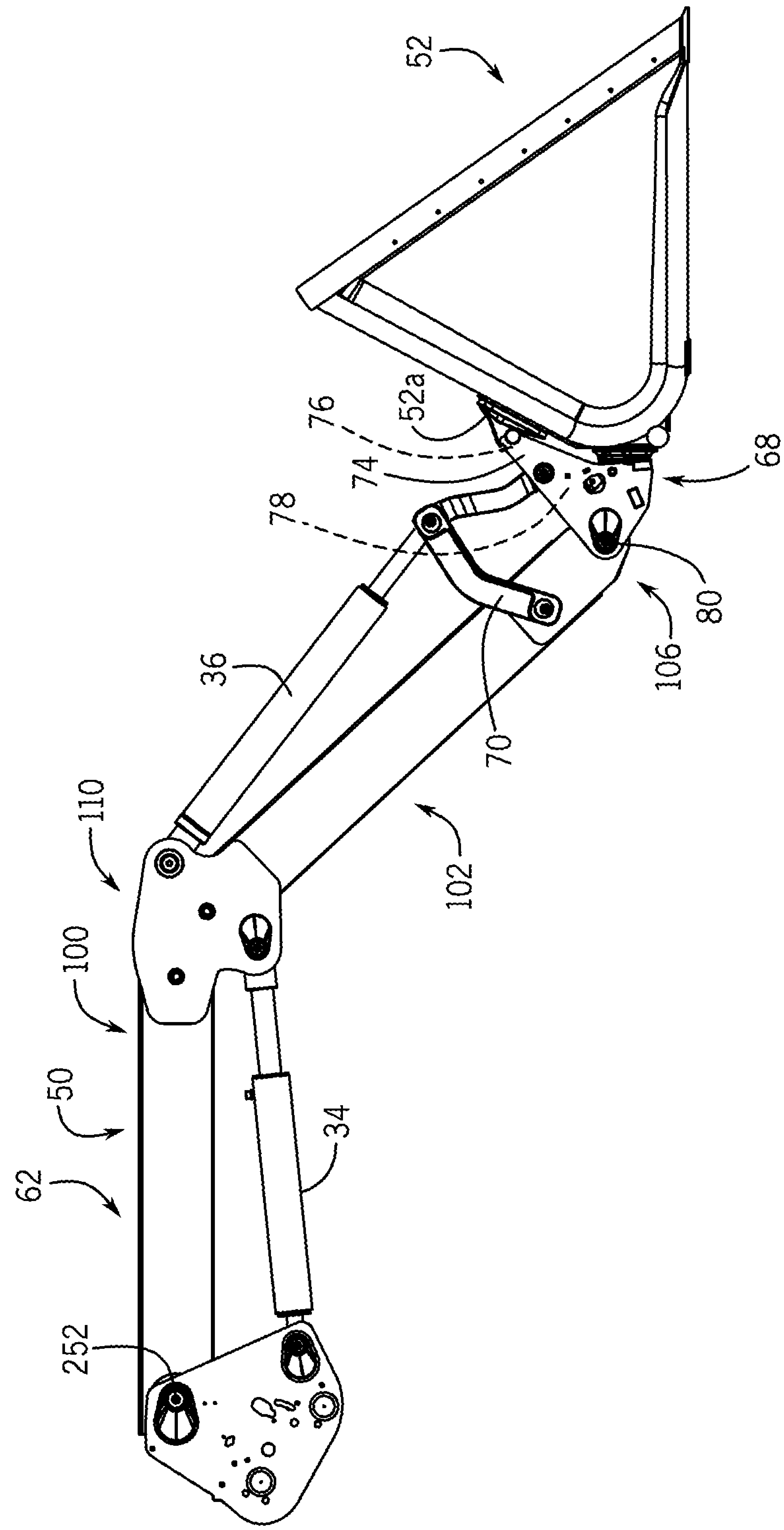
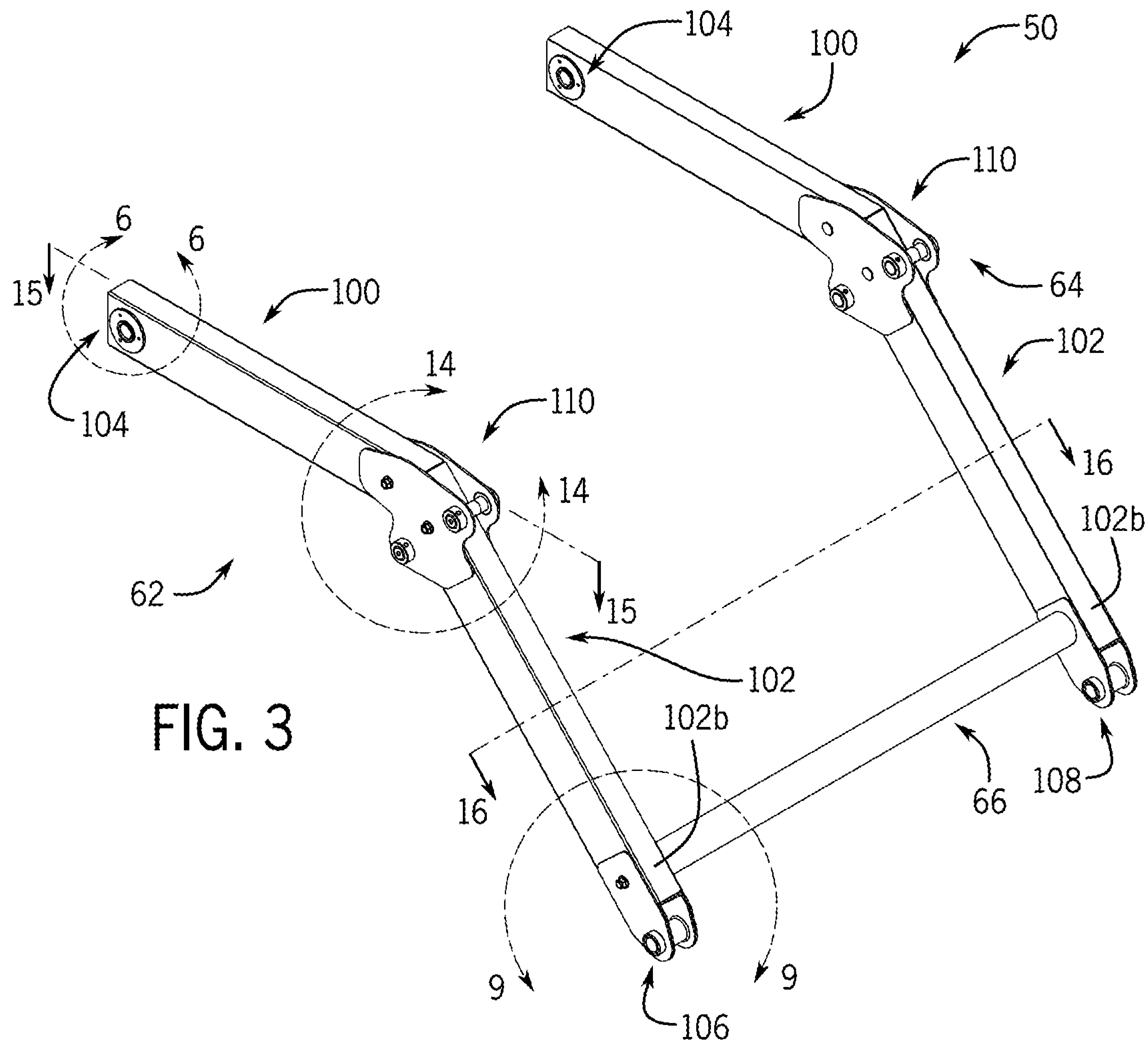


FIG. 2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16
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102b
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15
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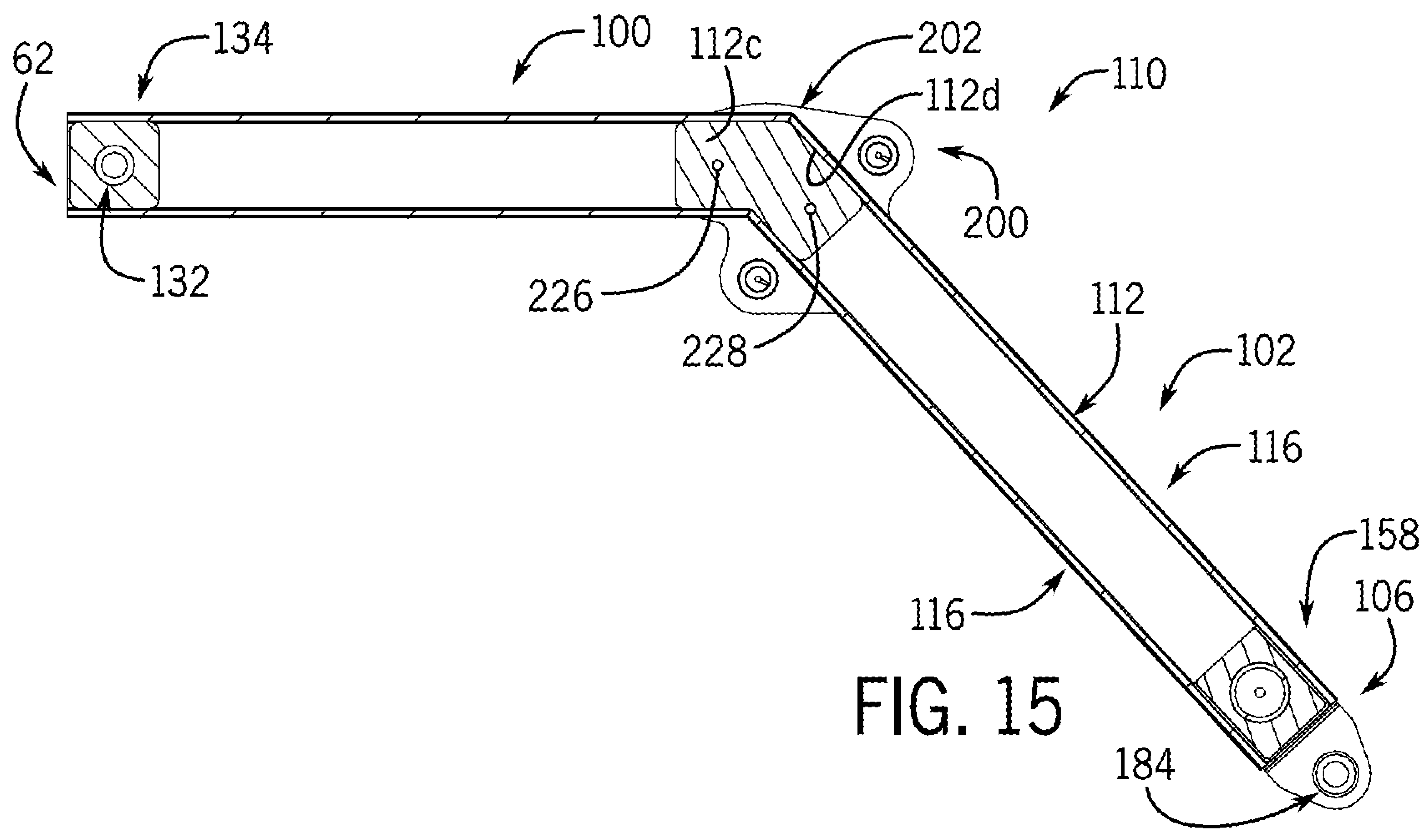
102b
16
66
108
9
9
106

FIG. 3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132
226
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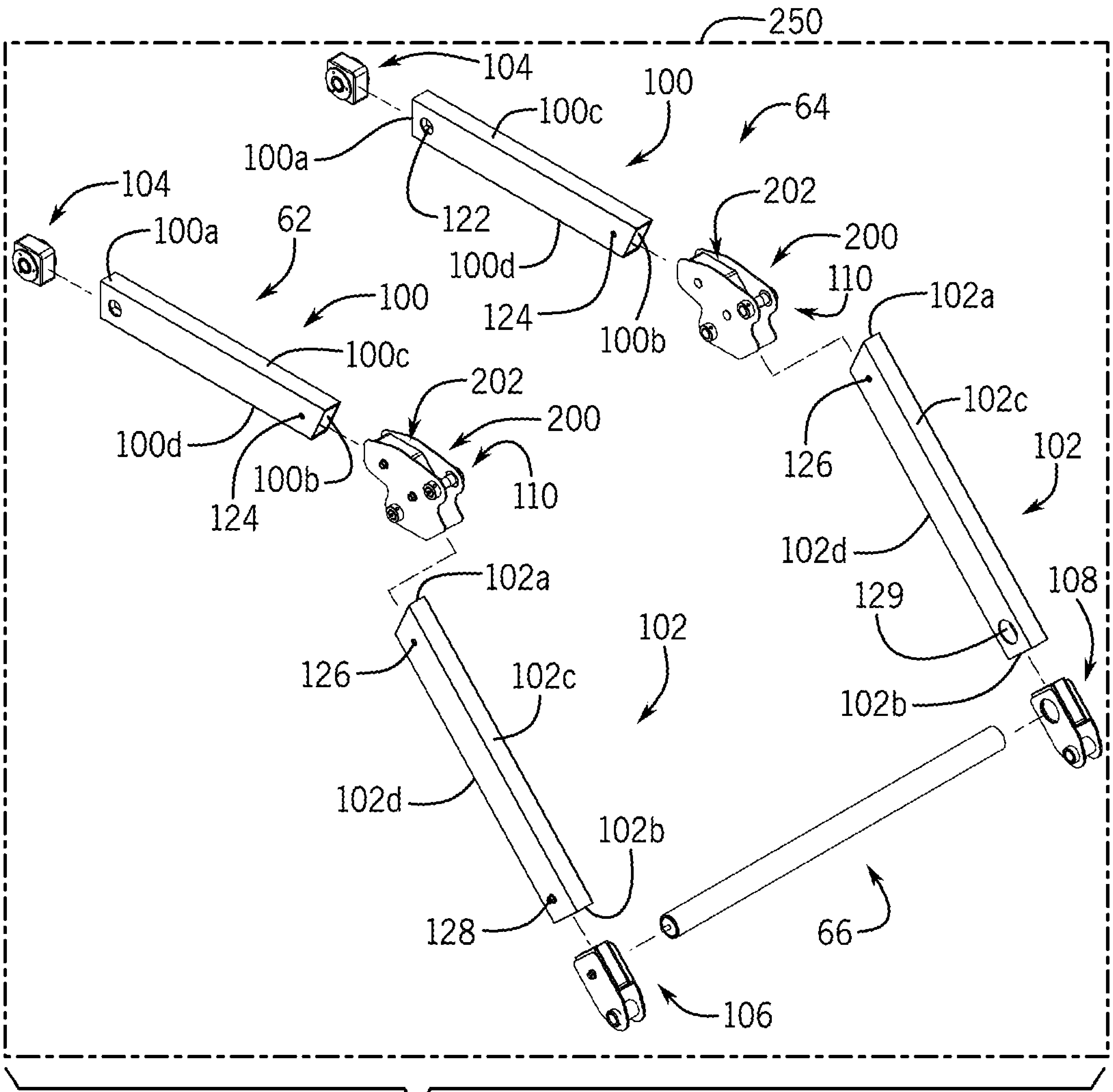
112
102
116
158
106
116
184

FIG. 15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100a
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202
100d
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100b
102a
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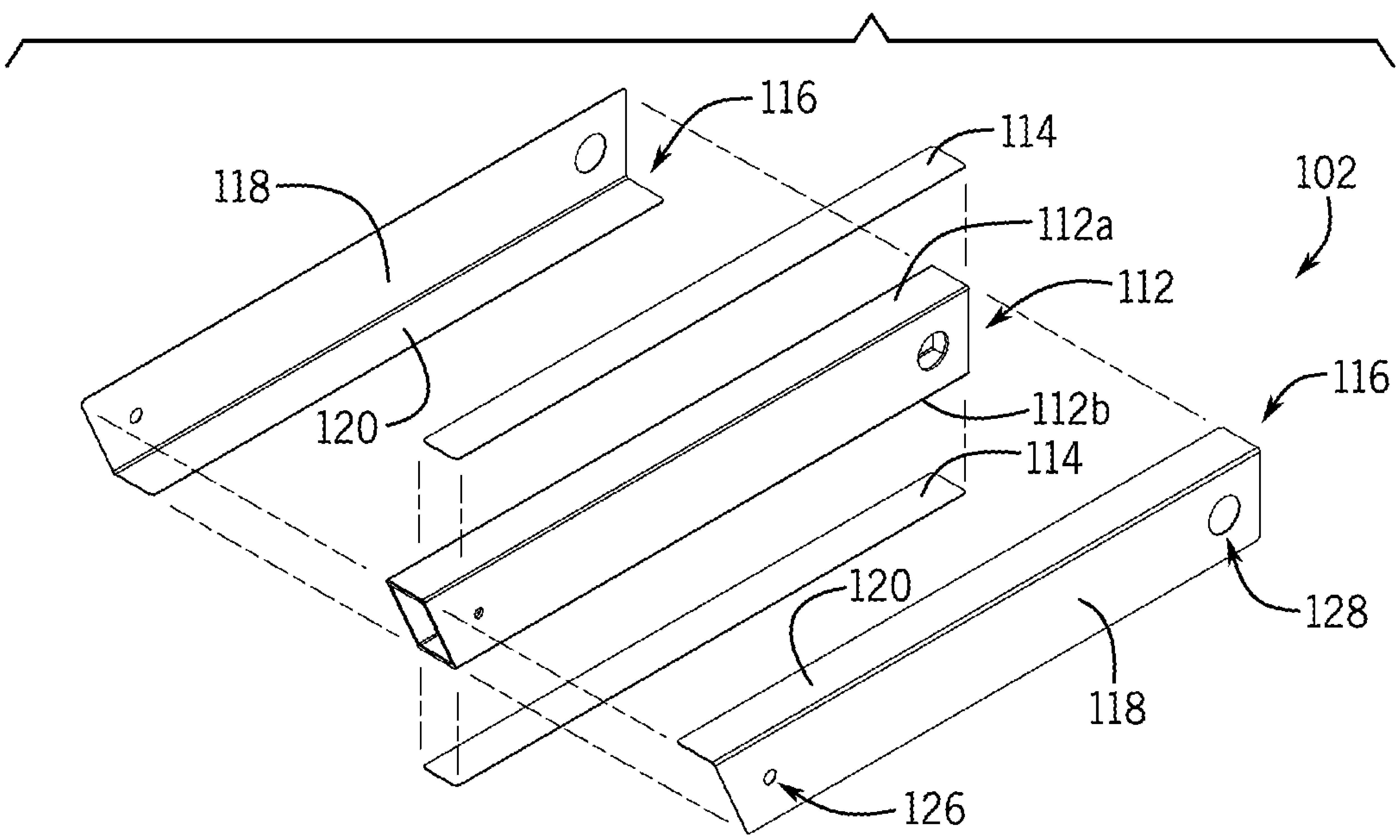
100c
202
200
102c
126
102
100d
124
100b
110
102d
102a
129
108
102
126
102c
102b
102d
102b
128
66
106

FIG. 5

FIG. 4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112b
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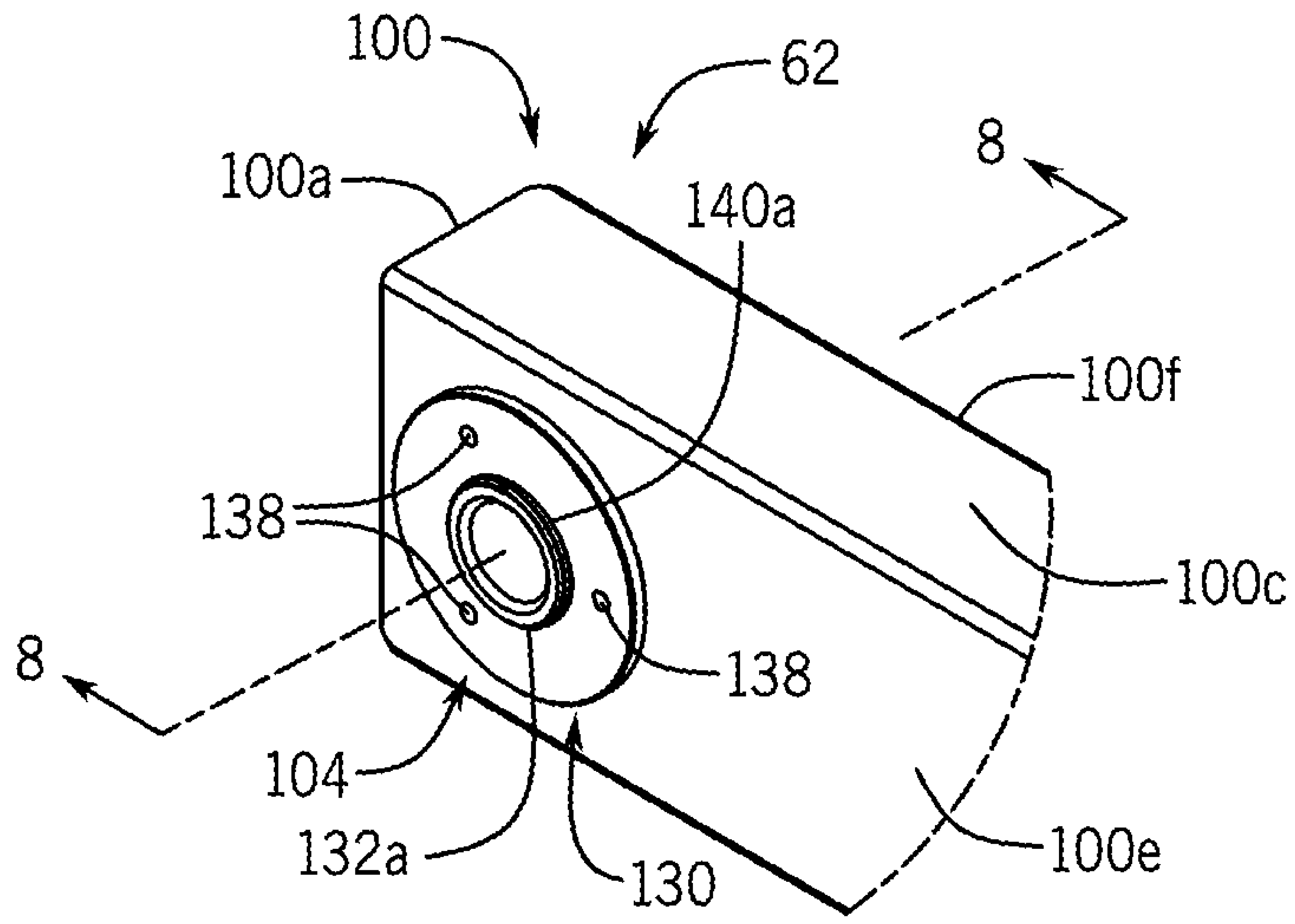
116
120
128
118
126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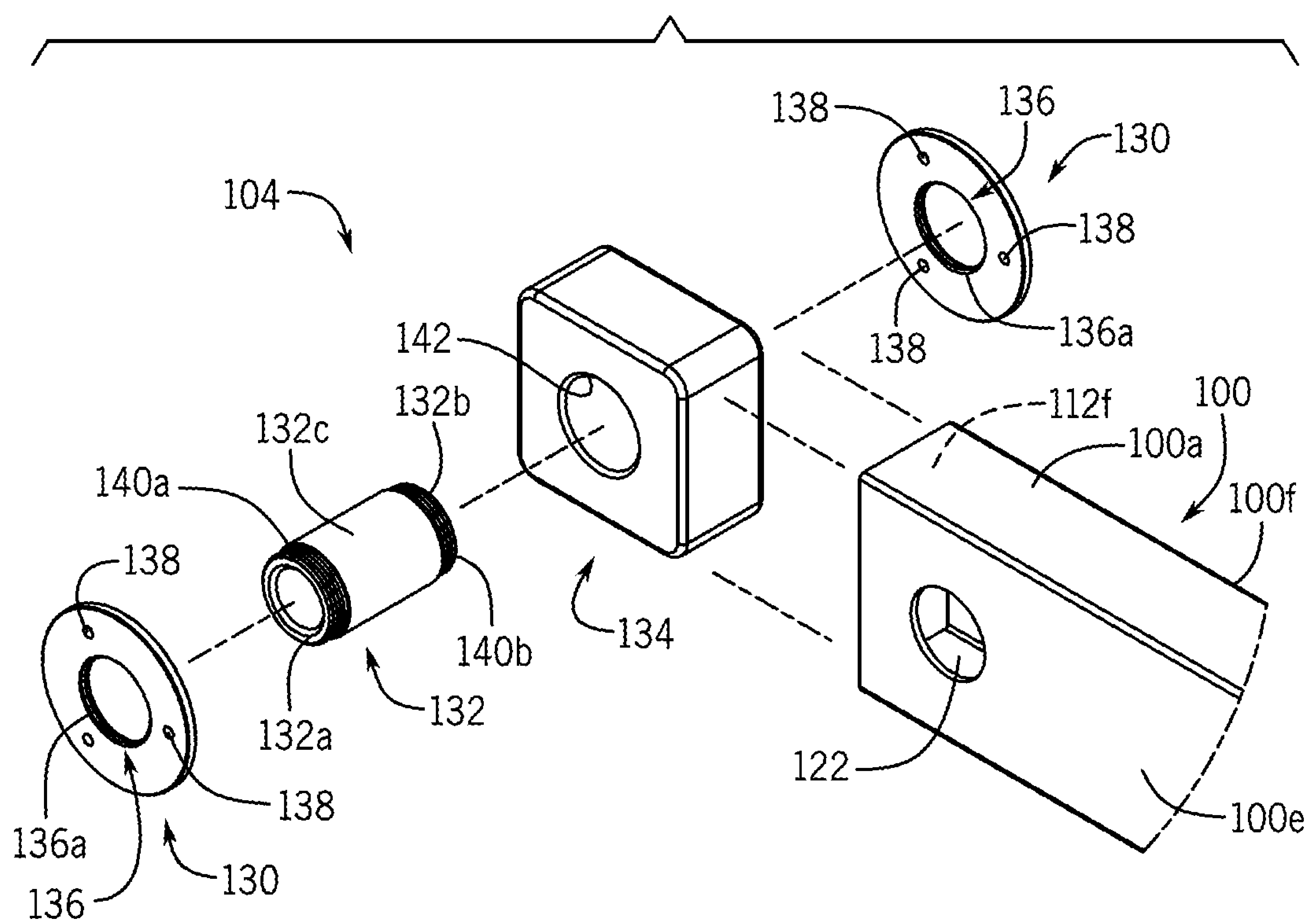
8
100a
140a
100f
138
100c
138
8
104
132a
130
100e

FIG. 6

FIG. 7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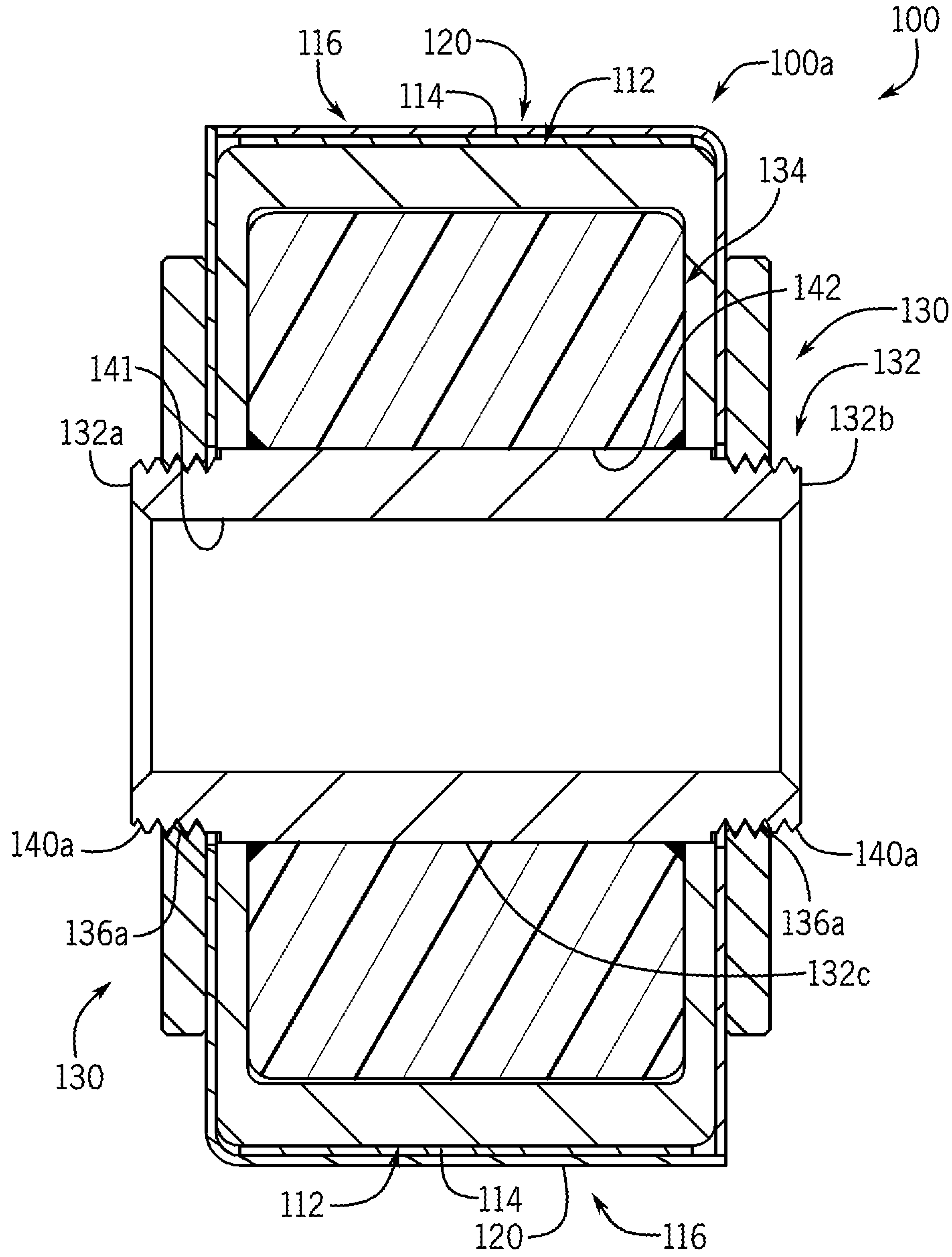
138
136a
130
136
100e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140a
136a
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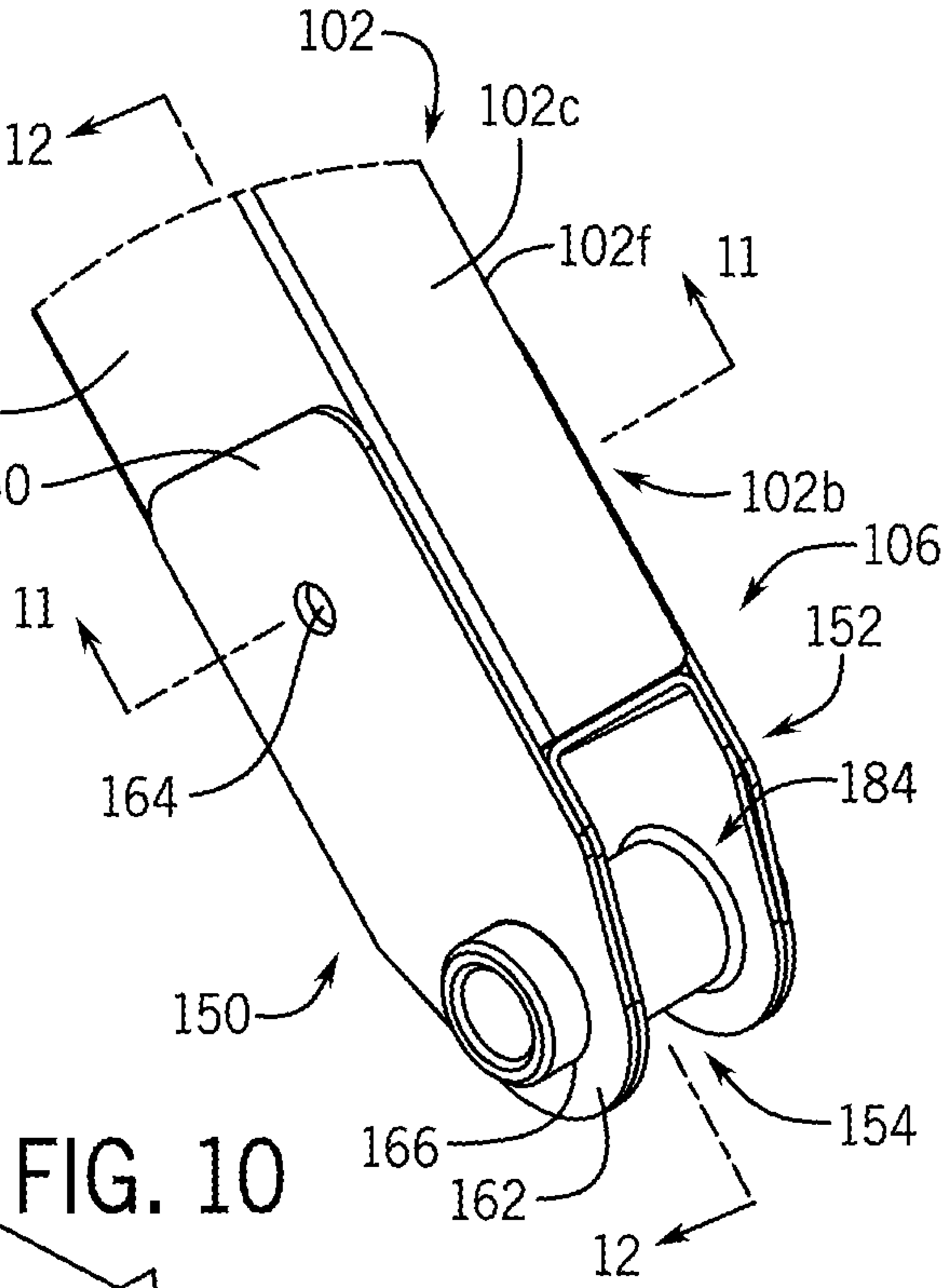
116

FIG. 8

FIG. 9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102e
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102b
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184
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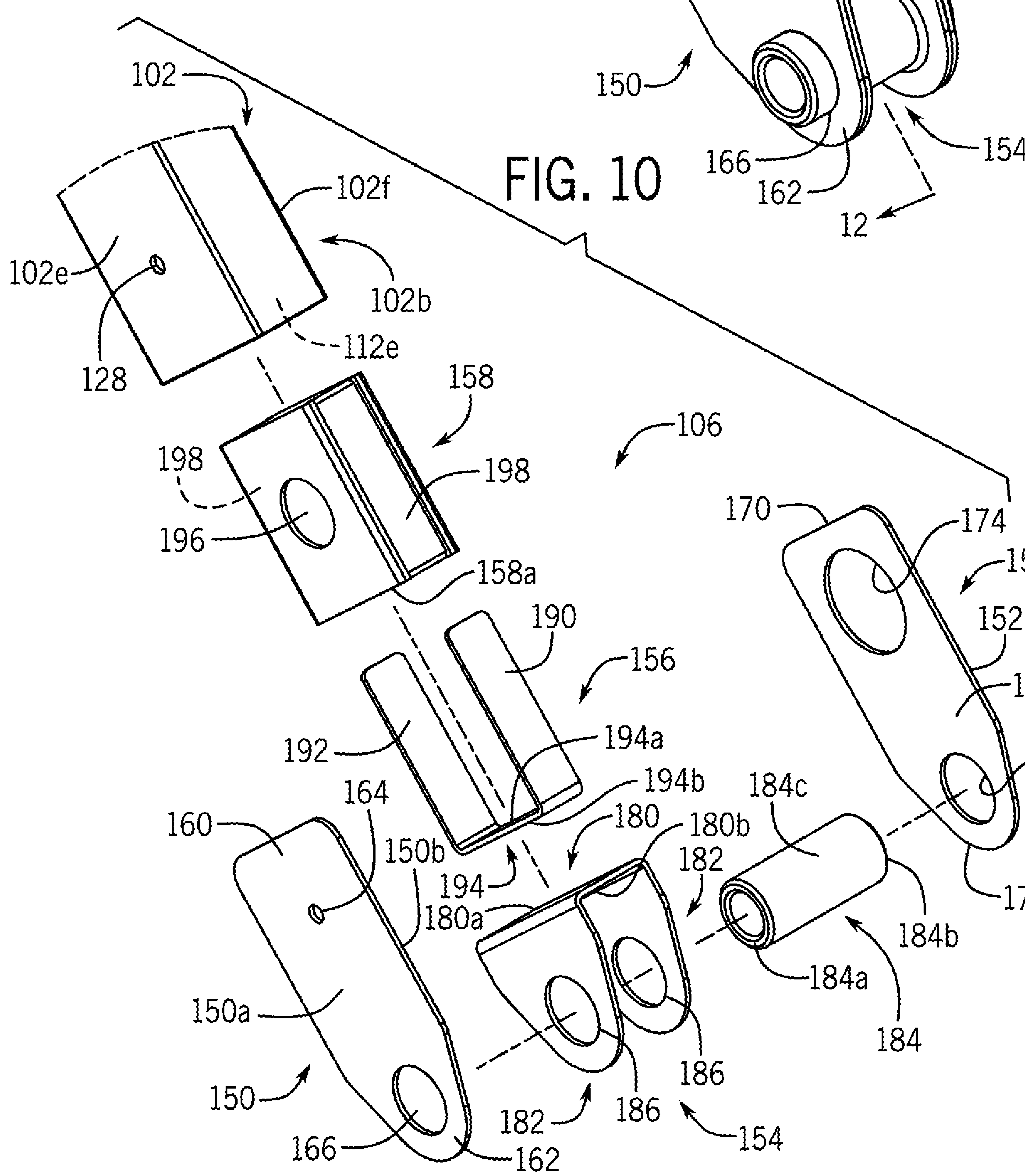
154
166
162
12

FIG. 10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102f
102e
102b
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112e
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198
198
106
196
170
174
152
158a
190
152b
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152a
192
194a
176
164
194b
184c
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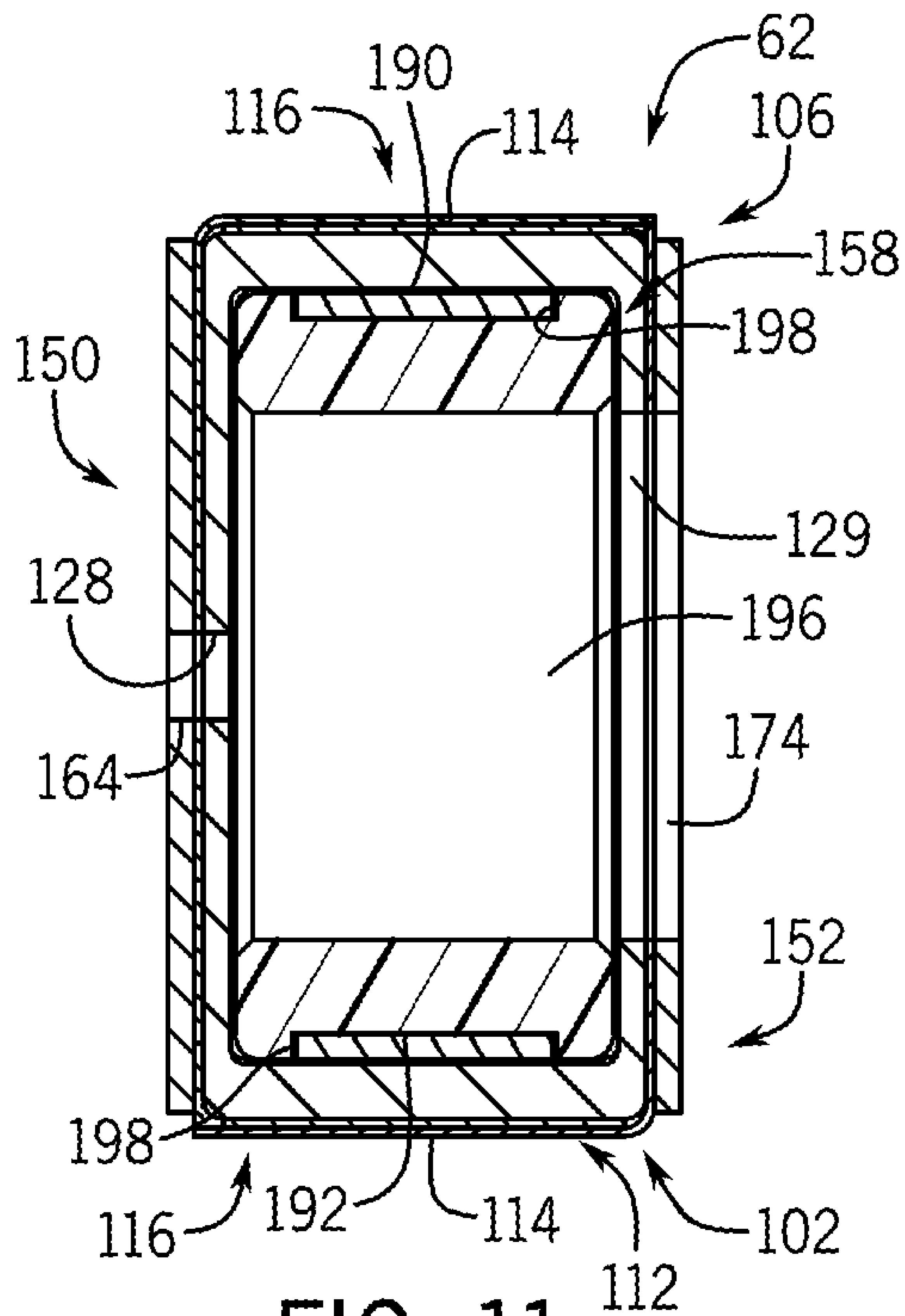
186
154
166
162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190
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128
196
164
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112
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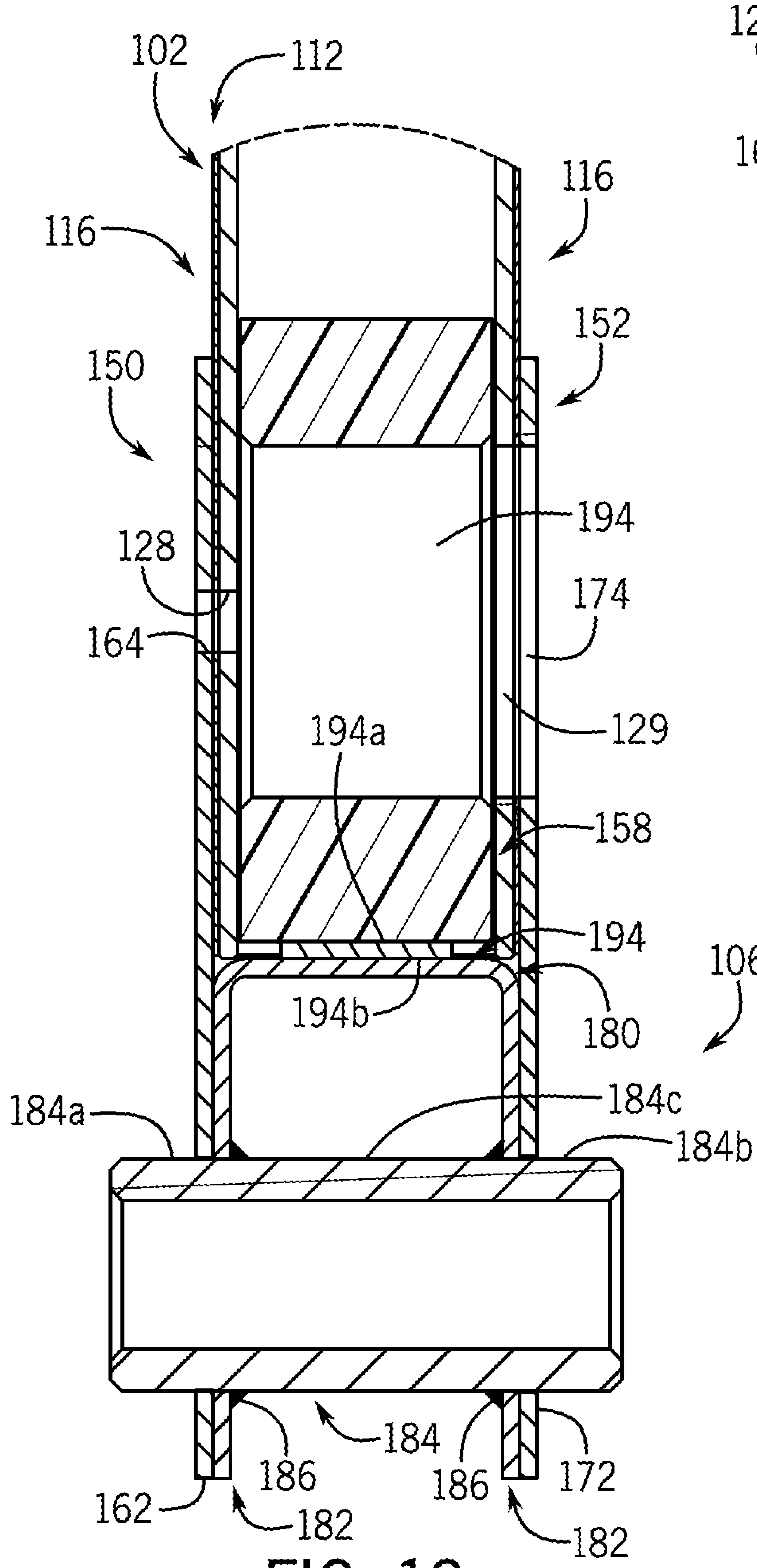
FIG. 11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186
186
172
162
182
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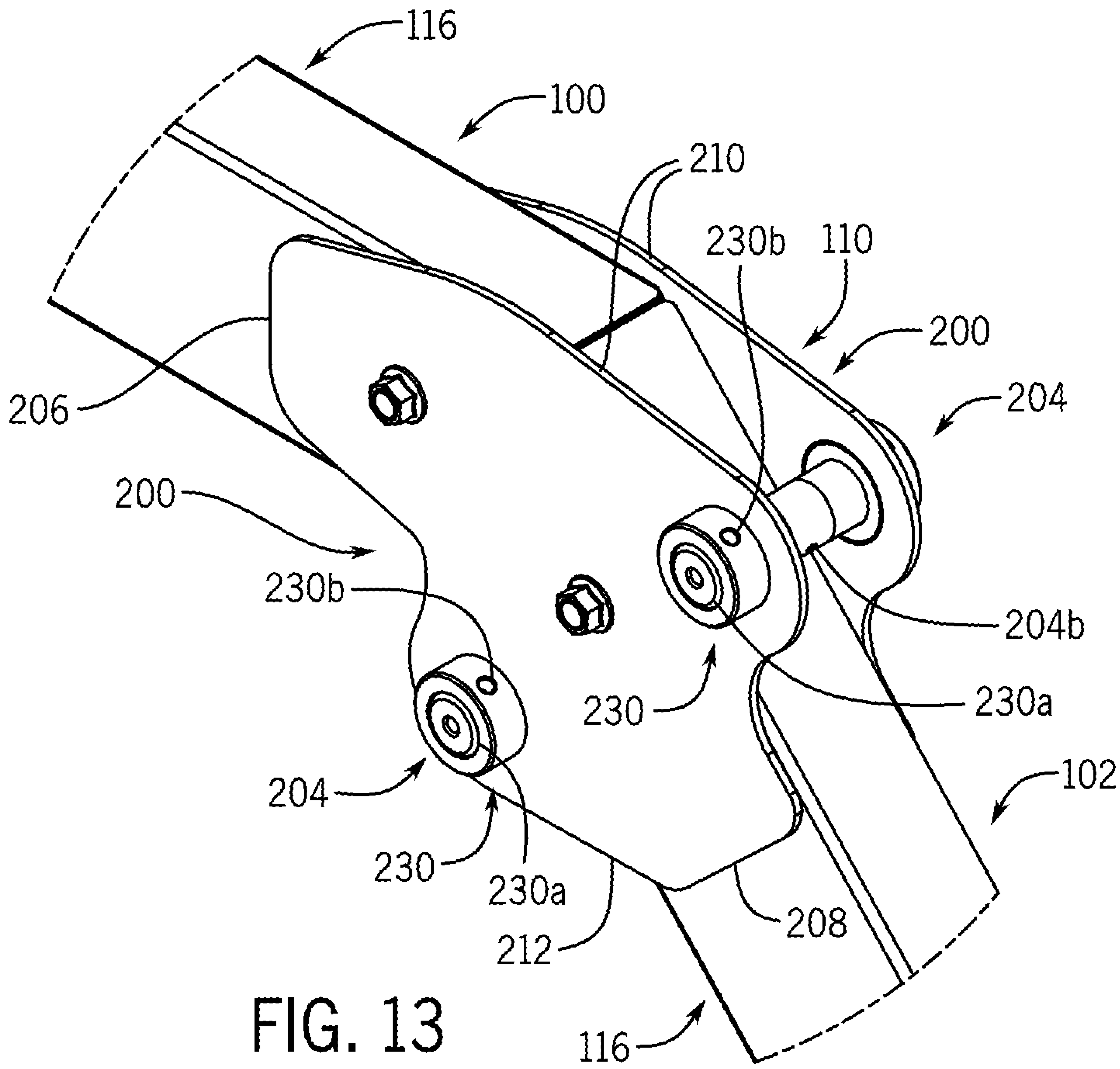
FIG. 12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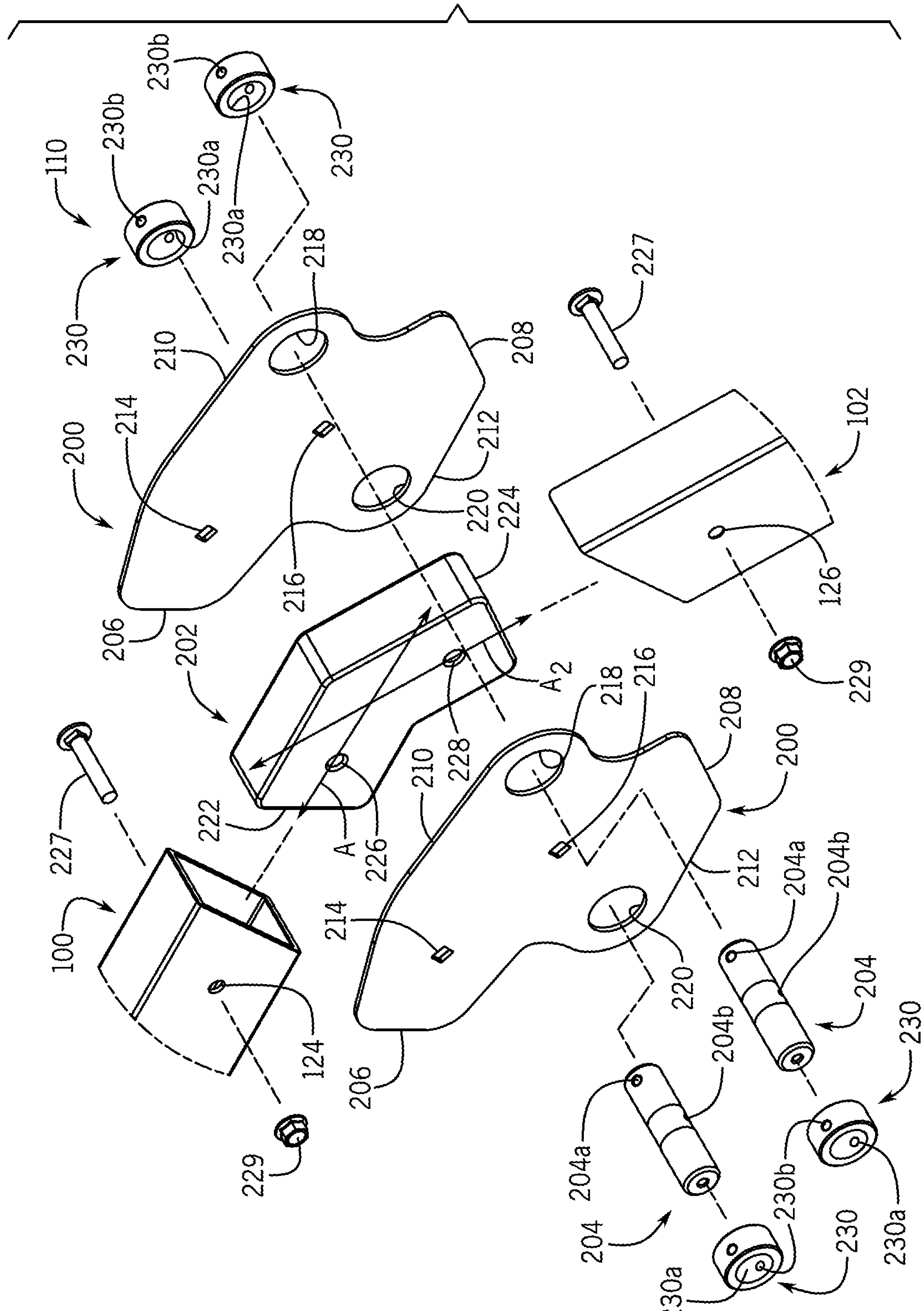
100
210
230b
110
200
204
206
200
230b
204b
230
230a
102
204
230
230a
212
208
116

FIG. 13

FIG. 14


110
230
230b
230a
230
200
210
214
218
208
212
220
224
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A_2
222
A
226
227
100
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229
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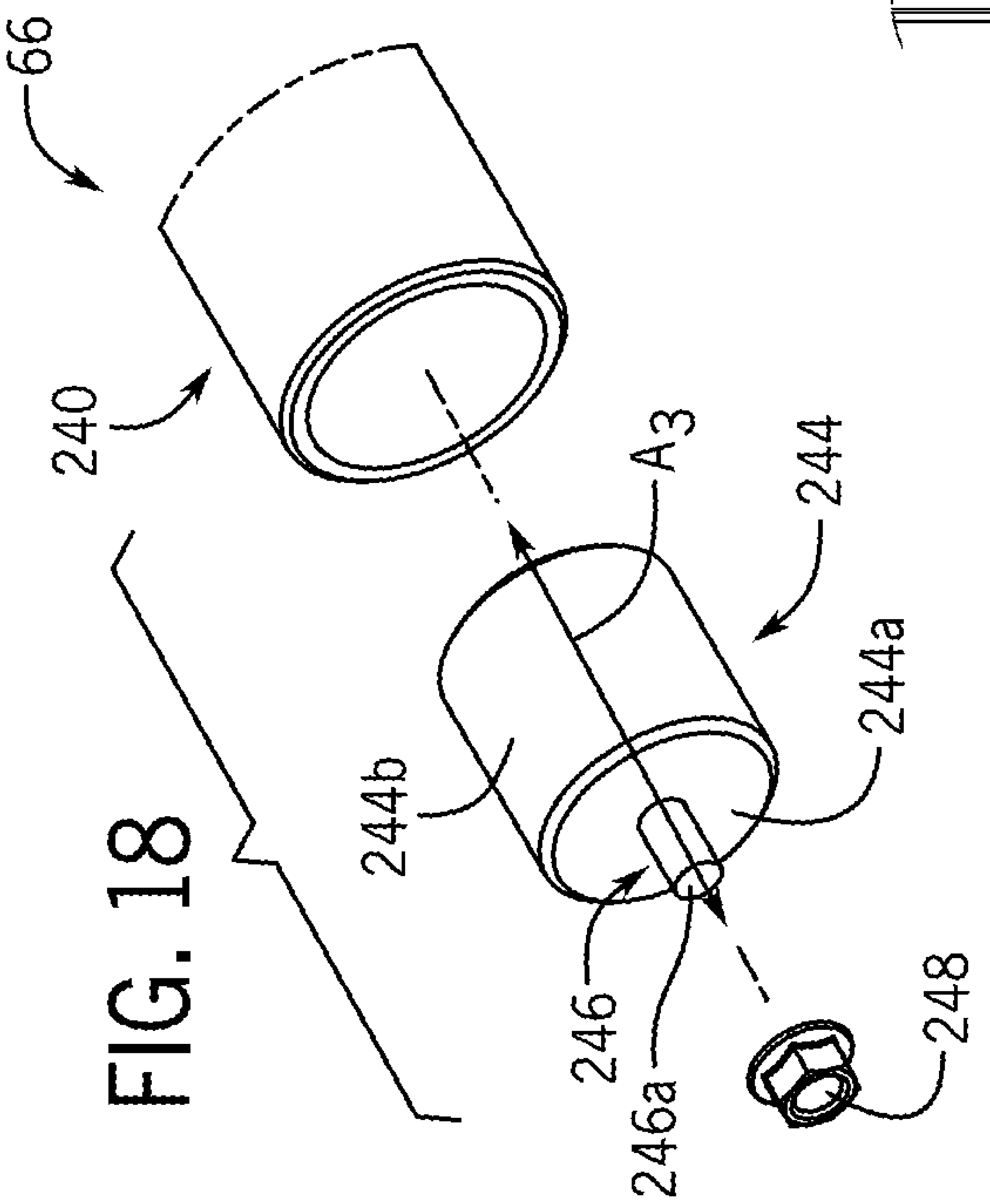
126
204
204a
204b



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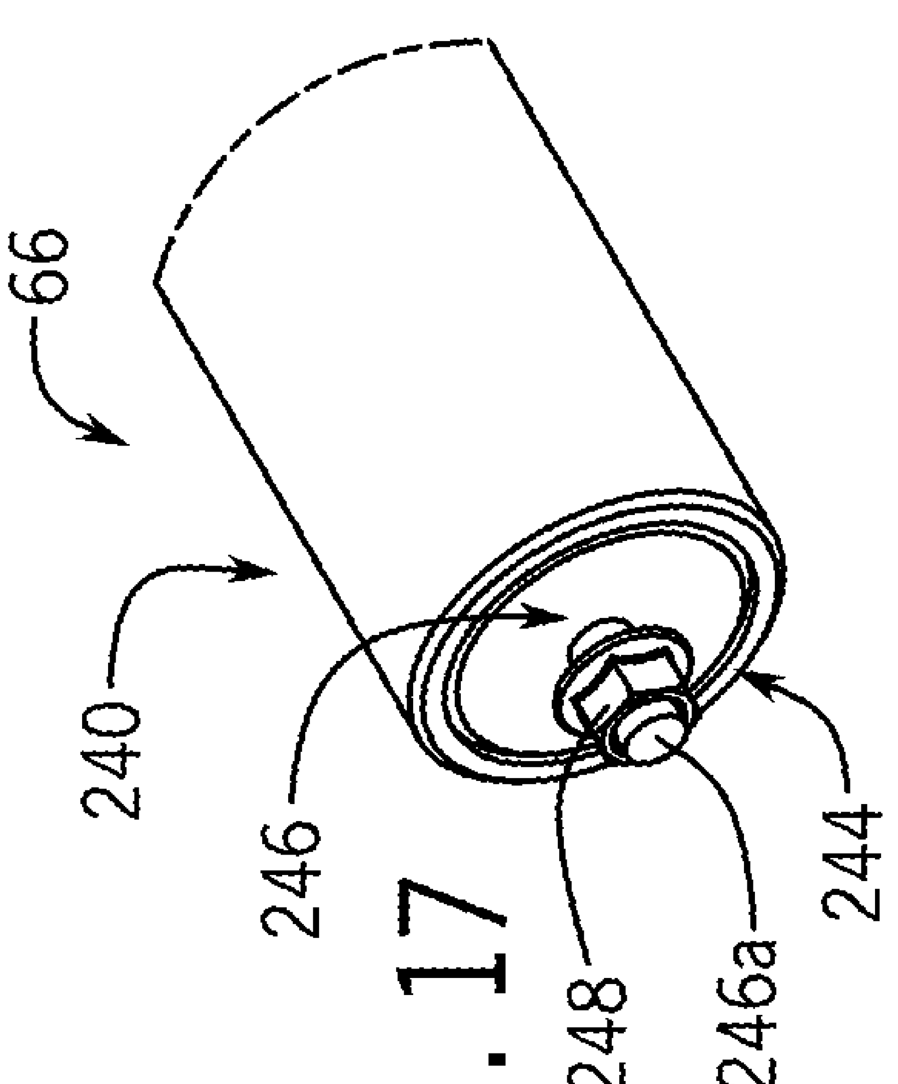

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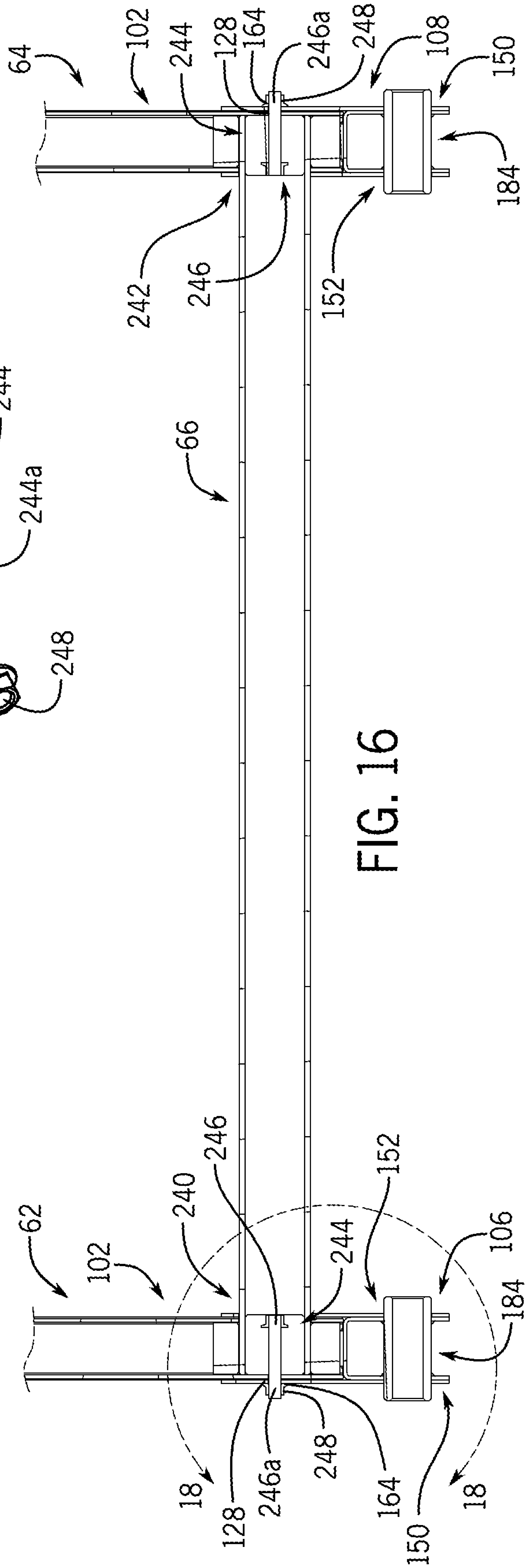
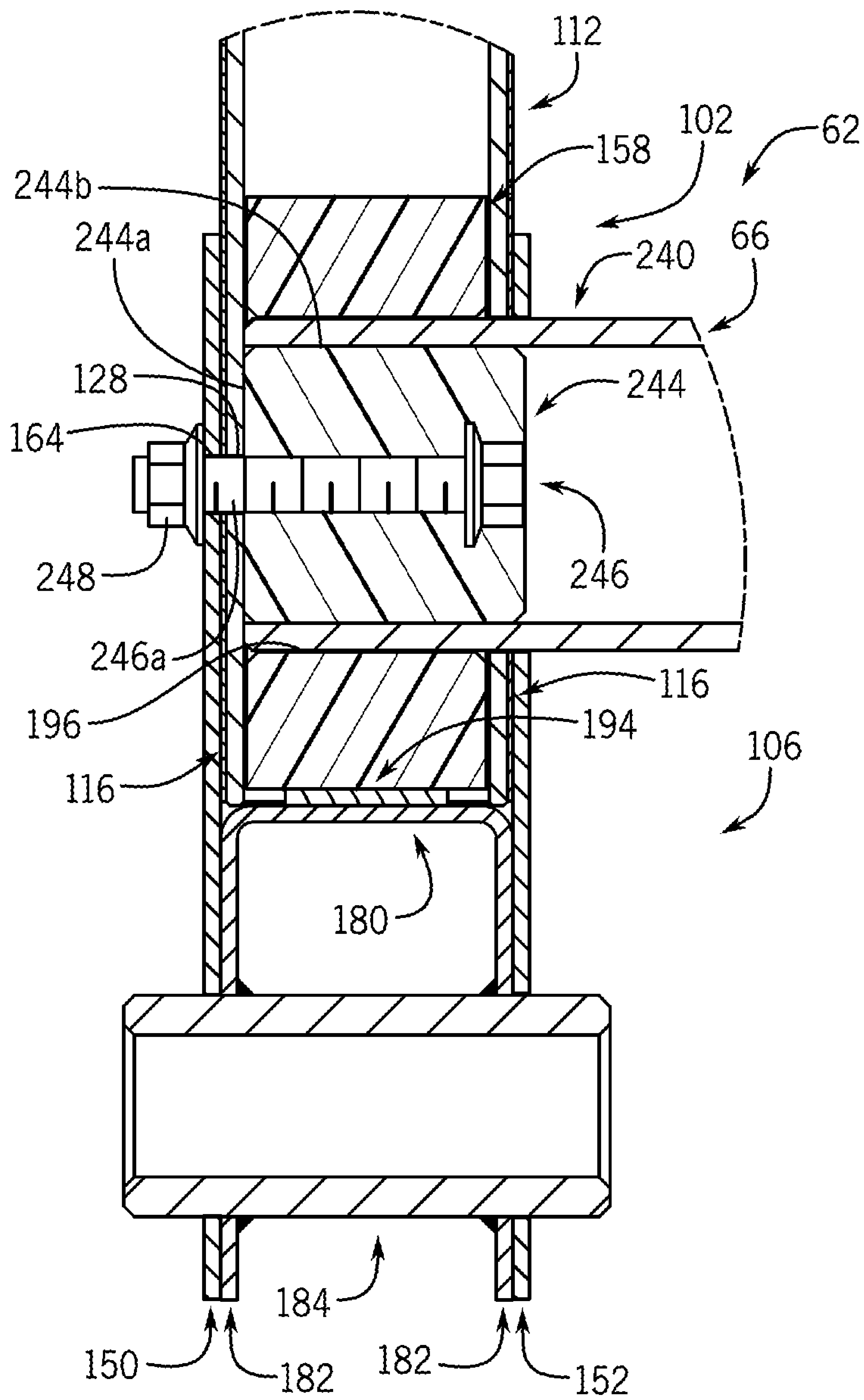


FIG. 16



112
102
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244a
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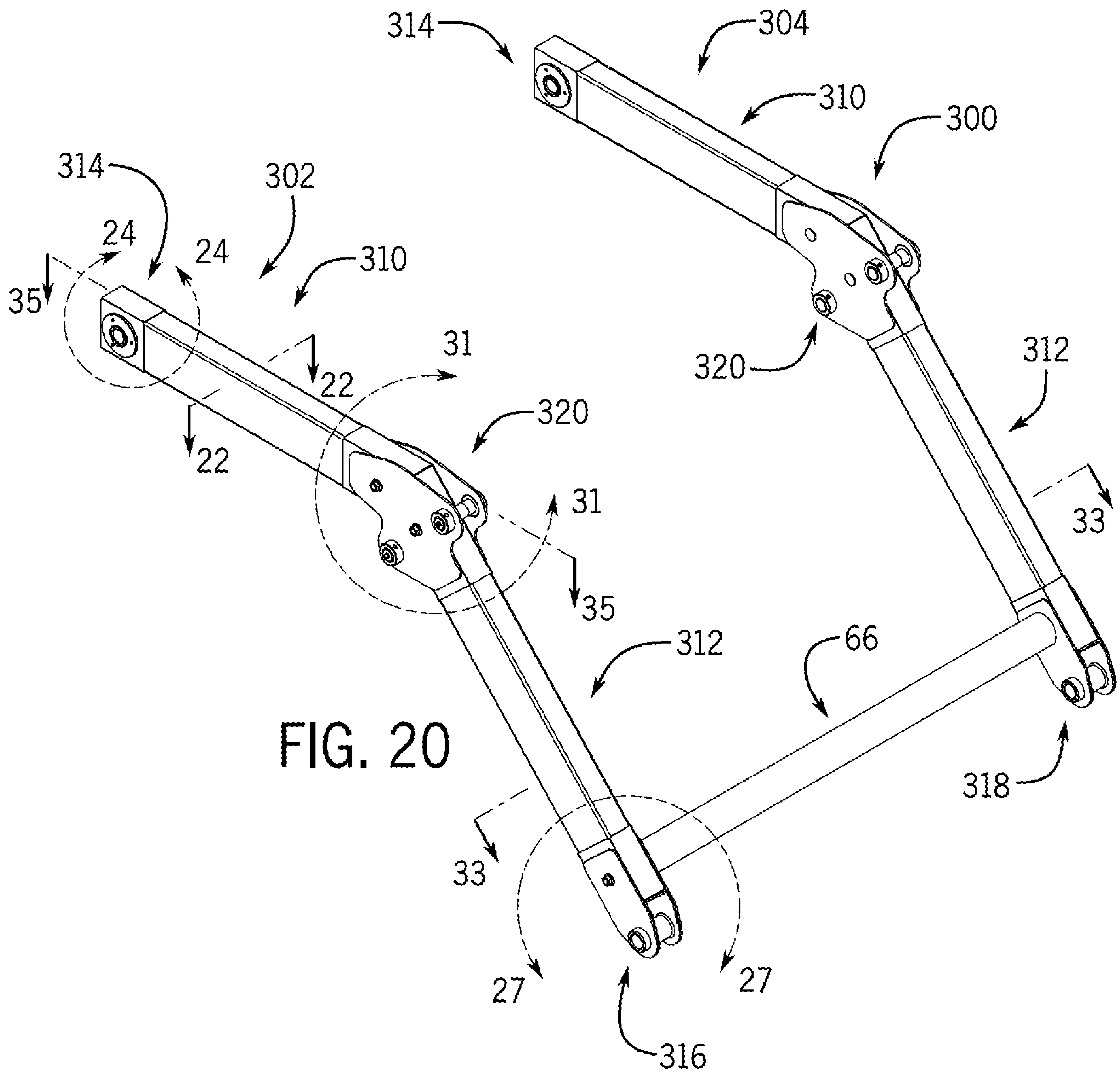
182
182
152

FIG. 19



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304
310
300
314
302
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24
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320
320
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312
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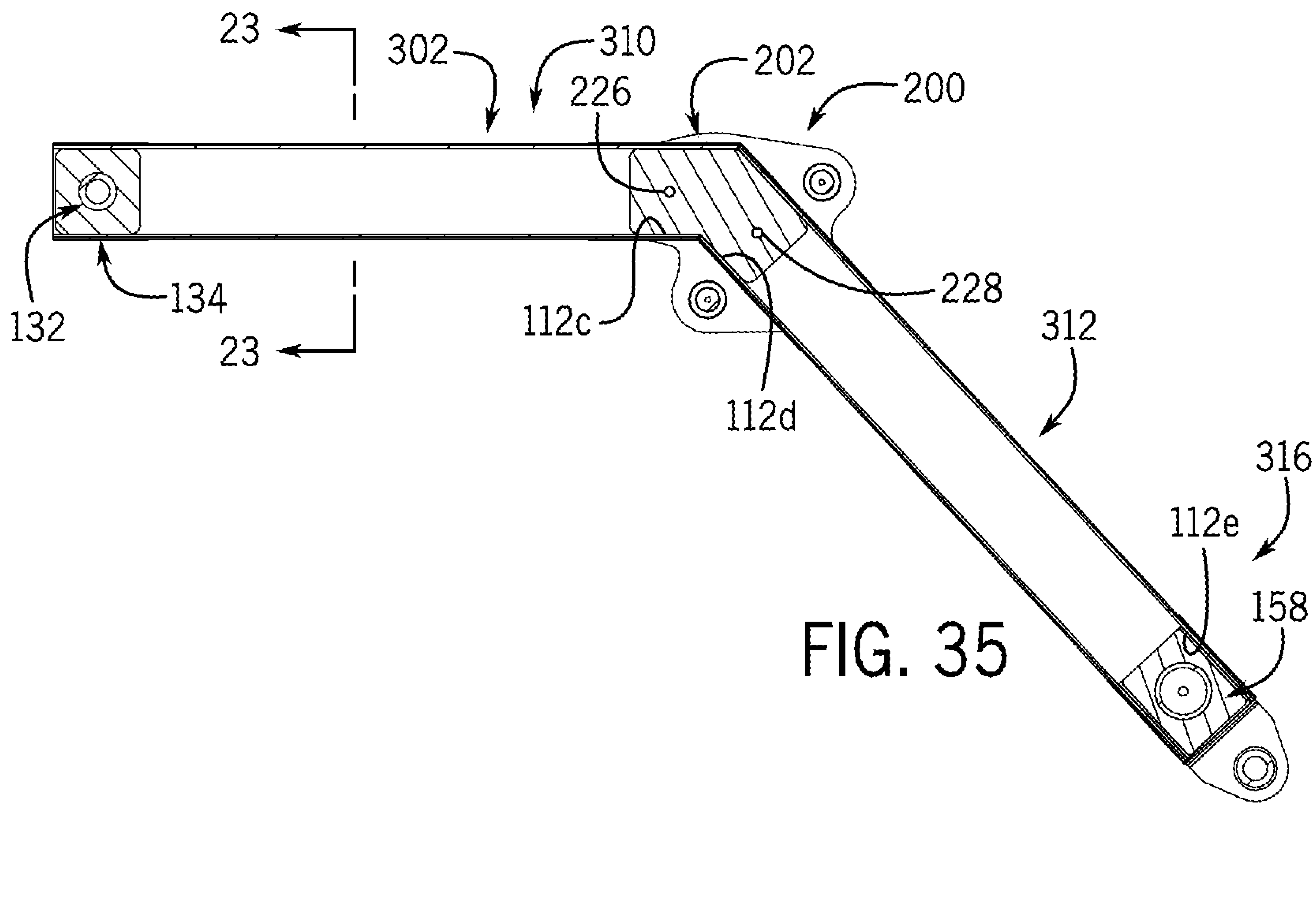
33
318
27
27
316

FIG. 20



23
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202
200
132
134
112c
228
23
312
112d
316
112e
158

FIG. 35

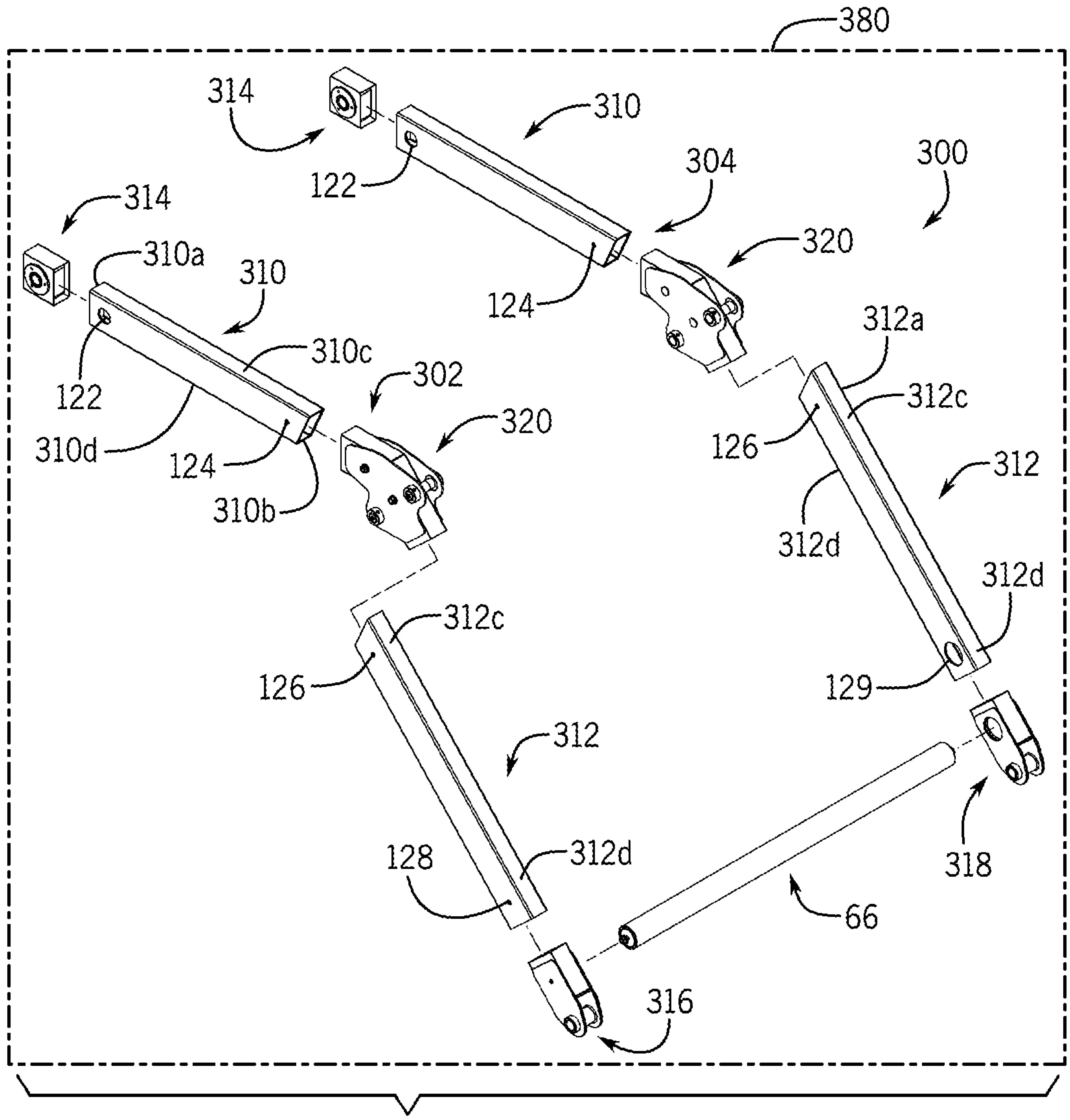
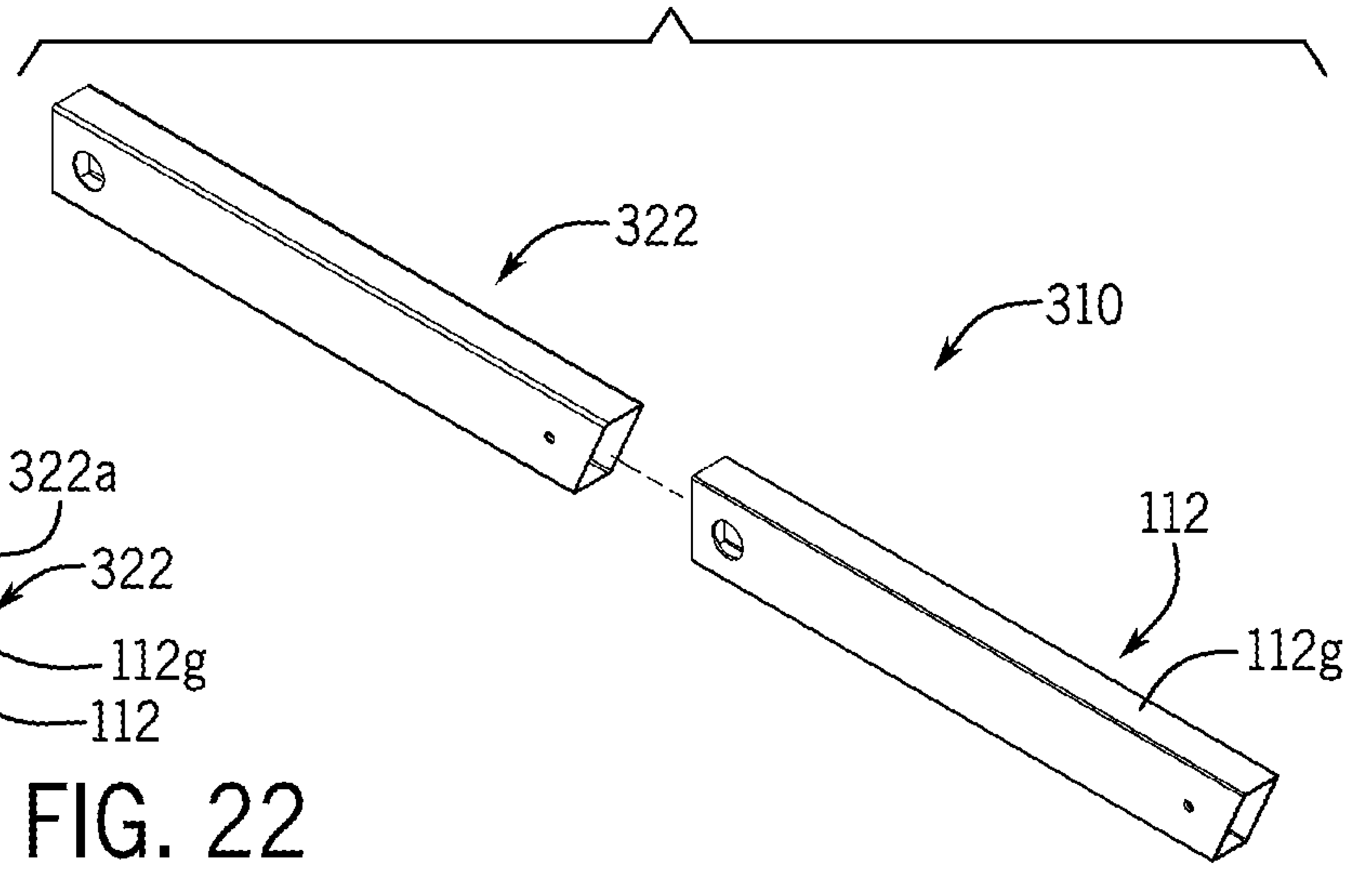
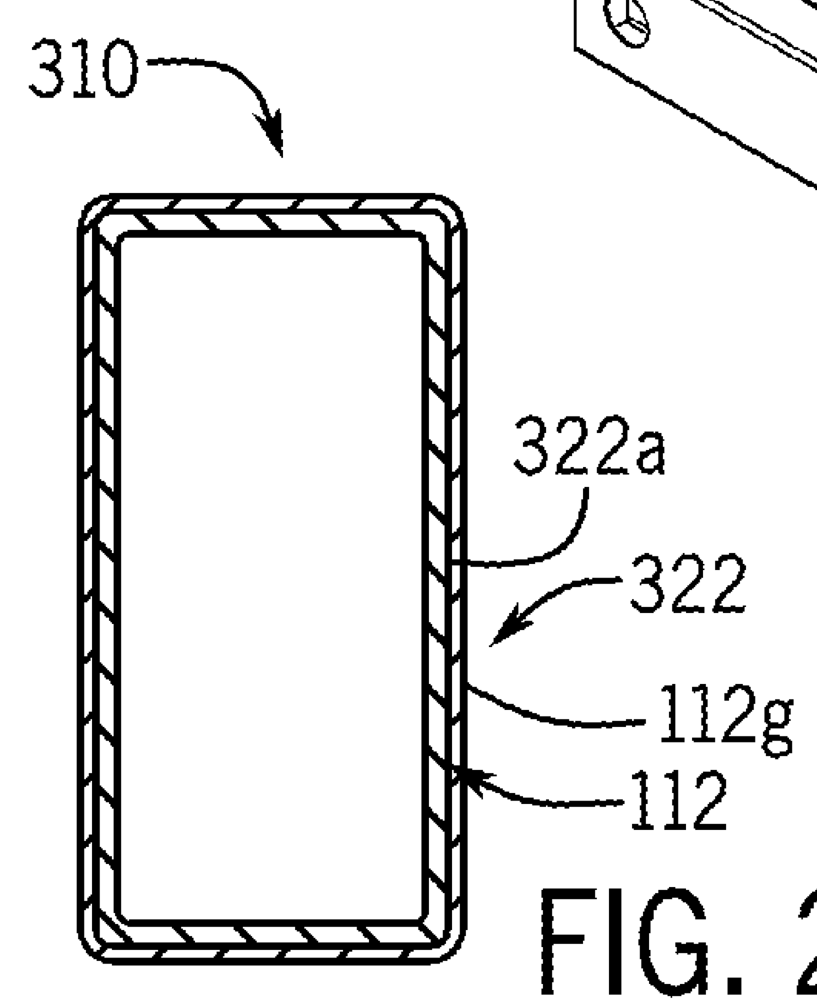


FIG. 23

FIG. 21





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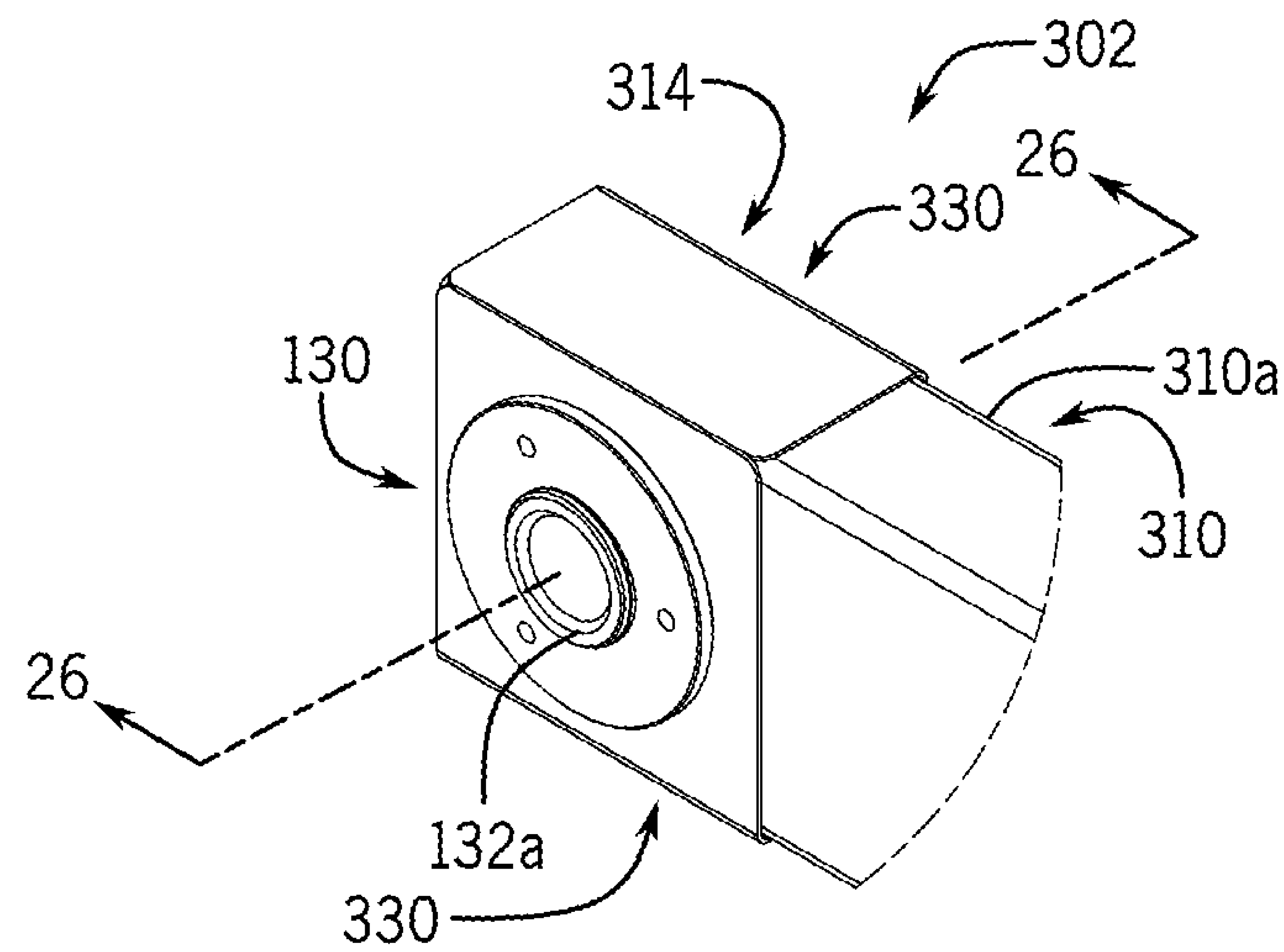
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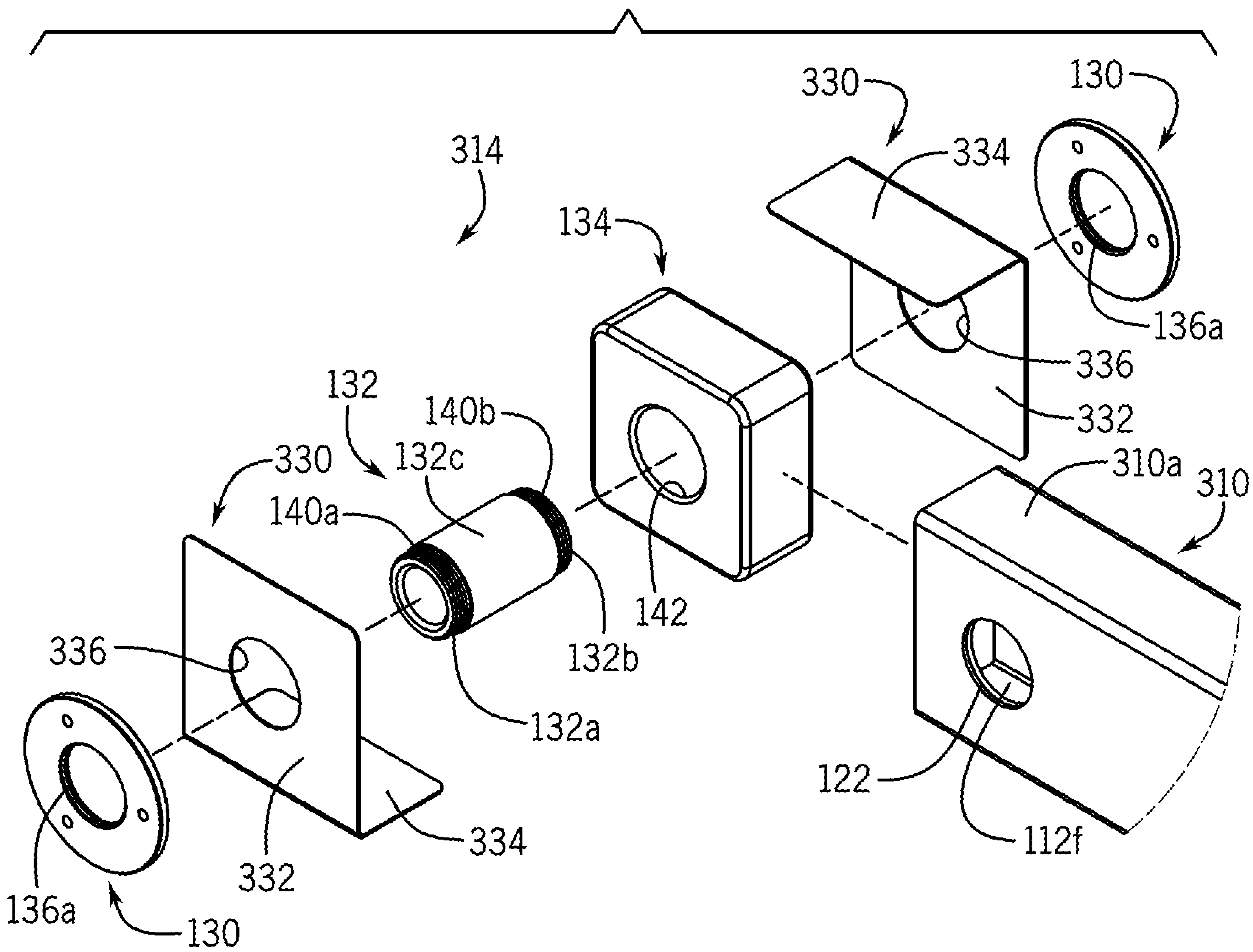
FIG. 24

FIG. 25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136a
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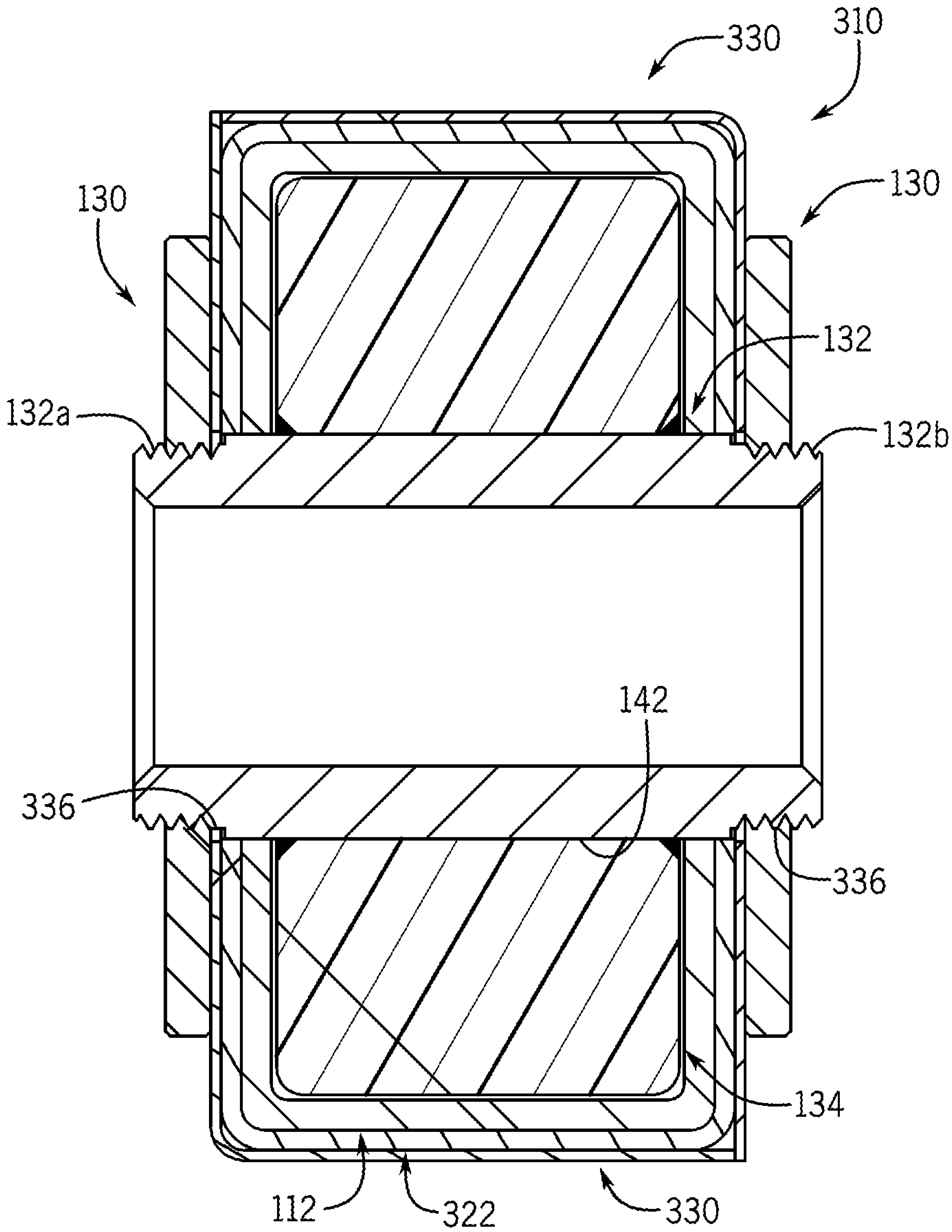

FIG. 26

FIG. 27

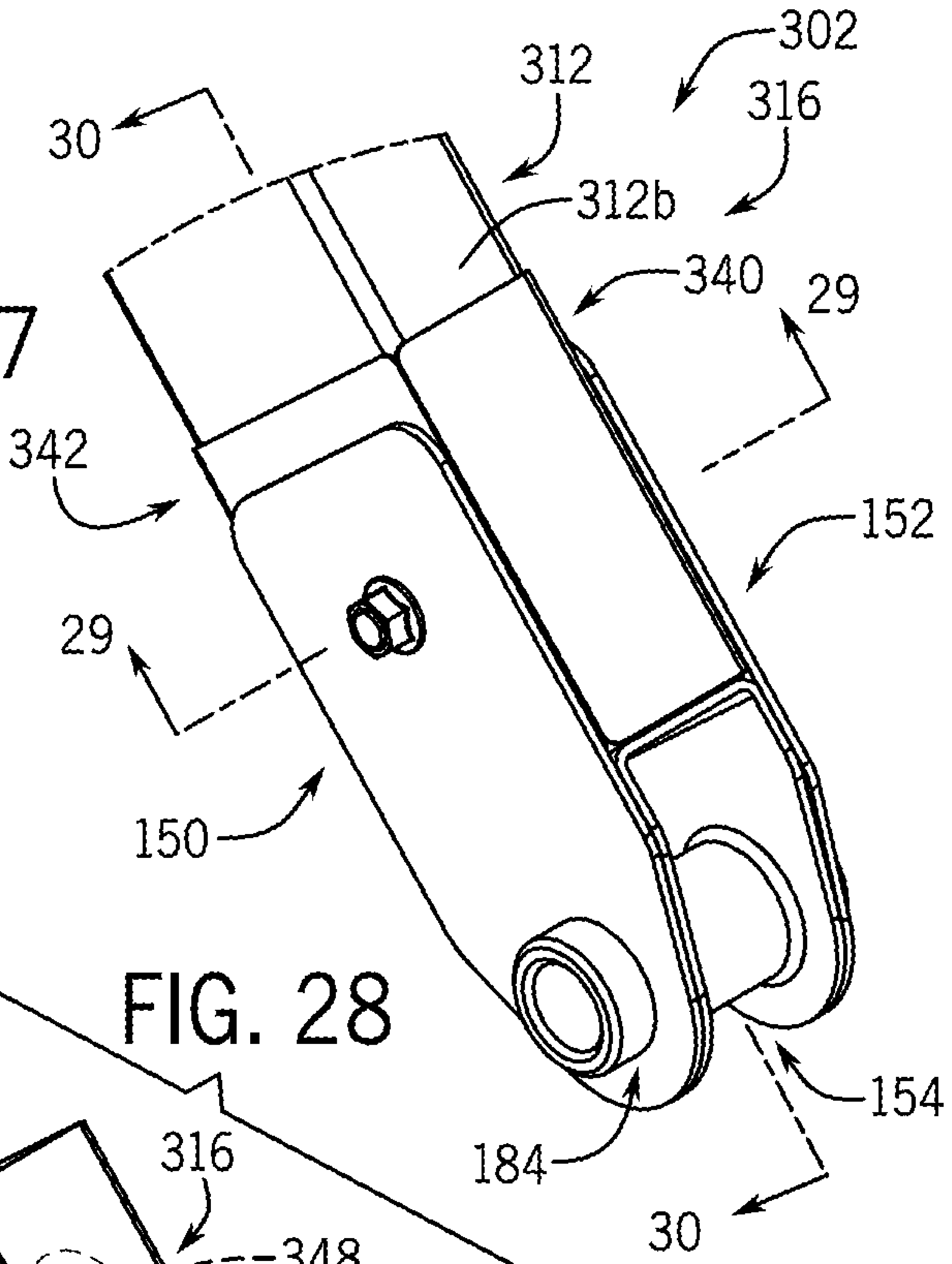
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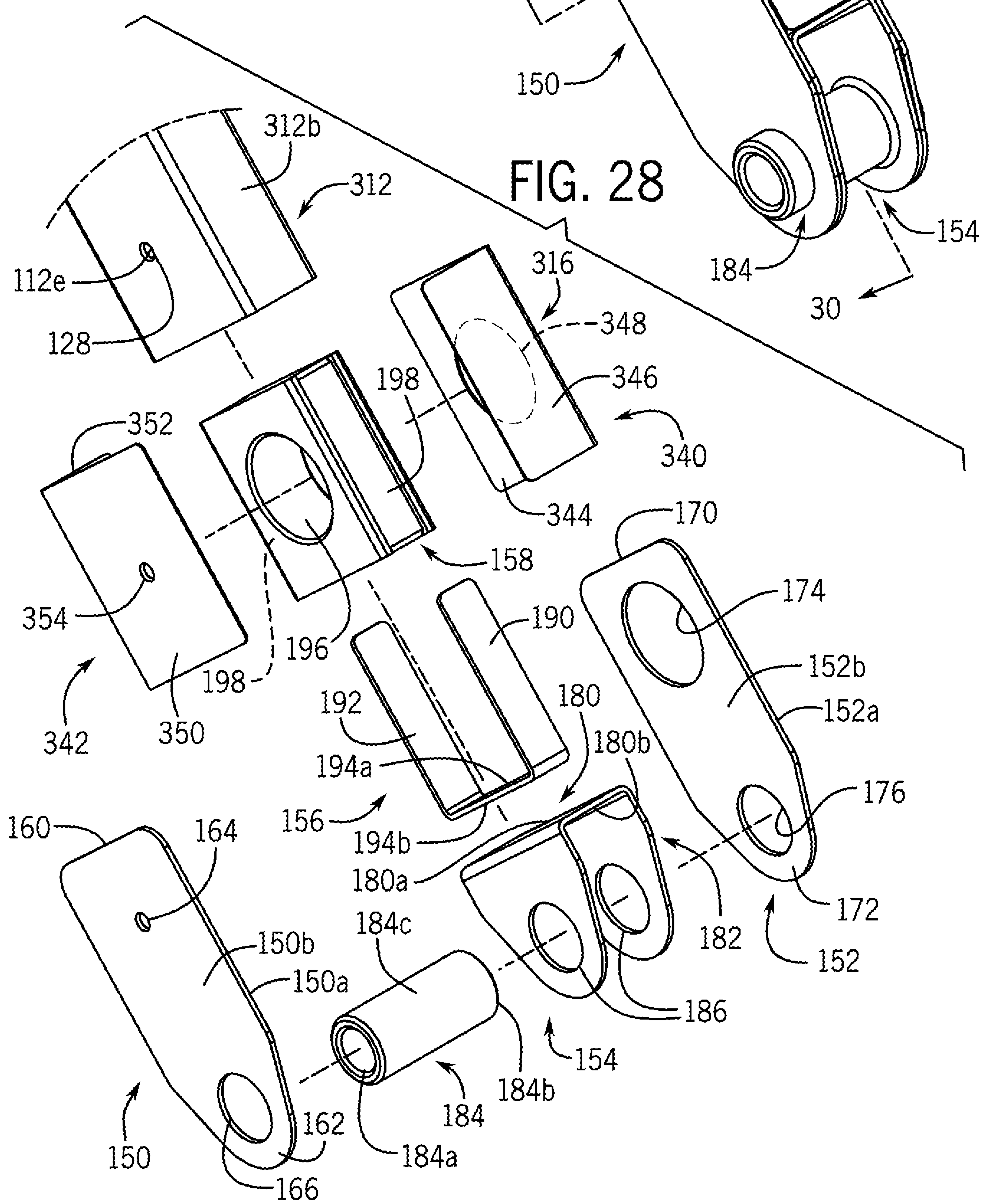
FIG. 28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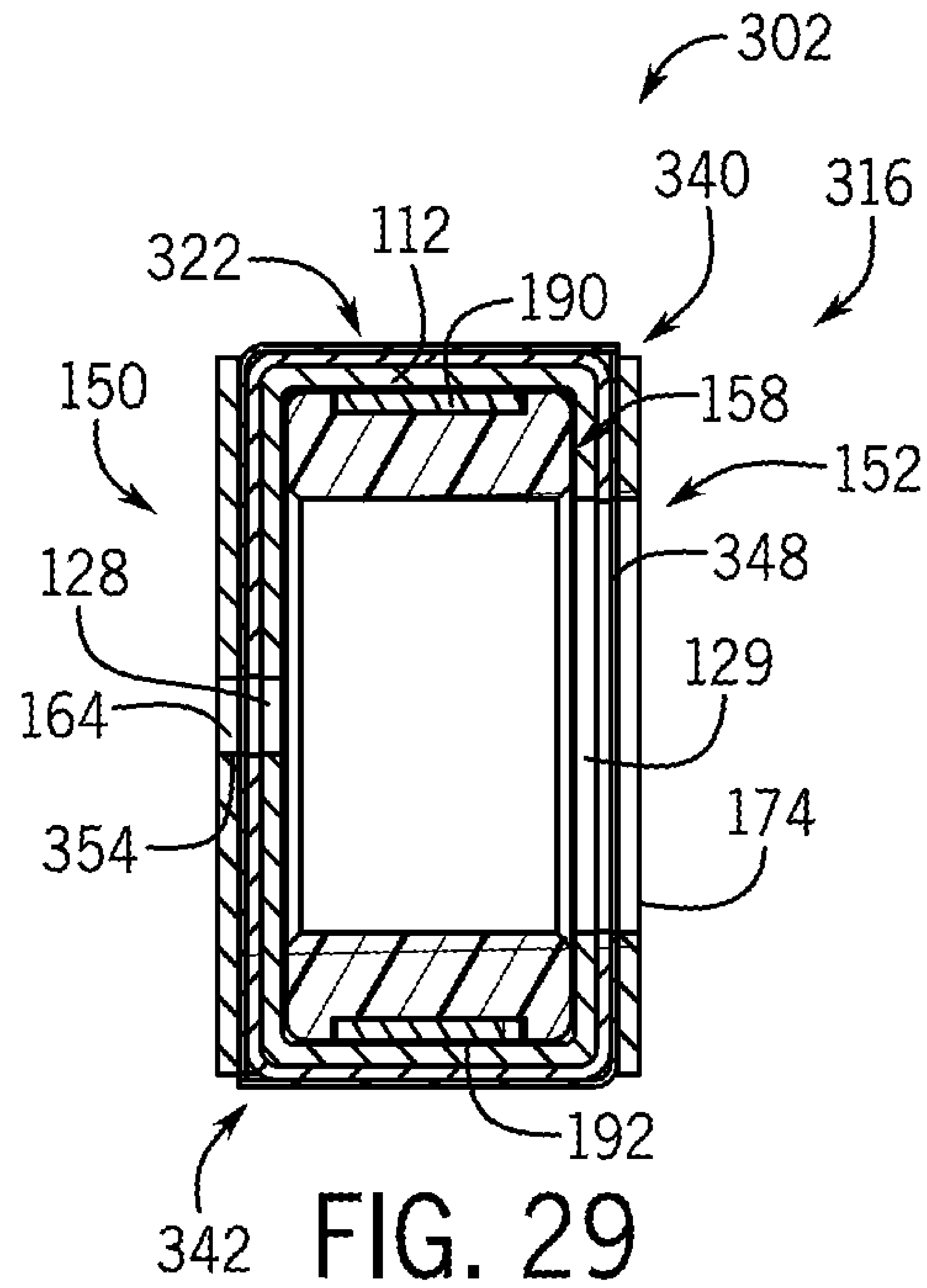
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FIG. 29

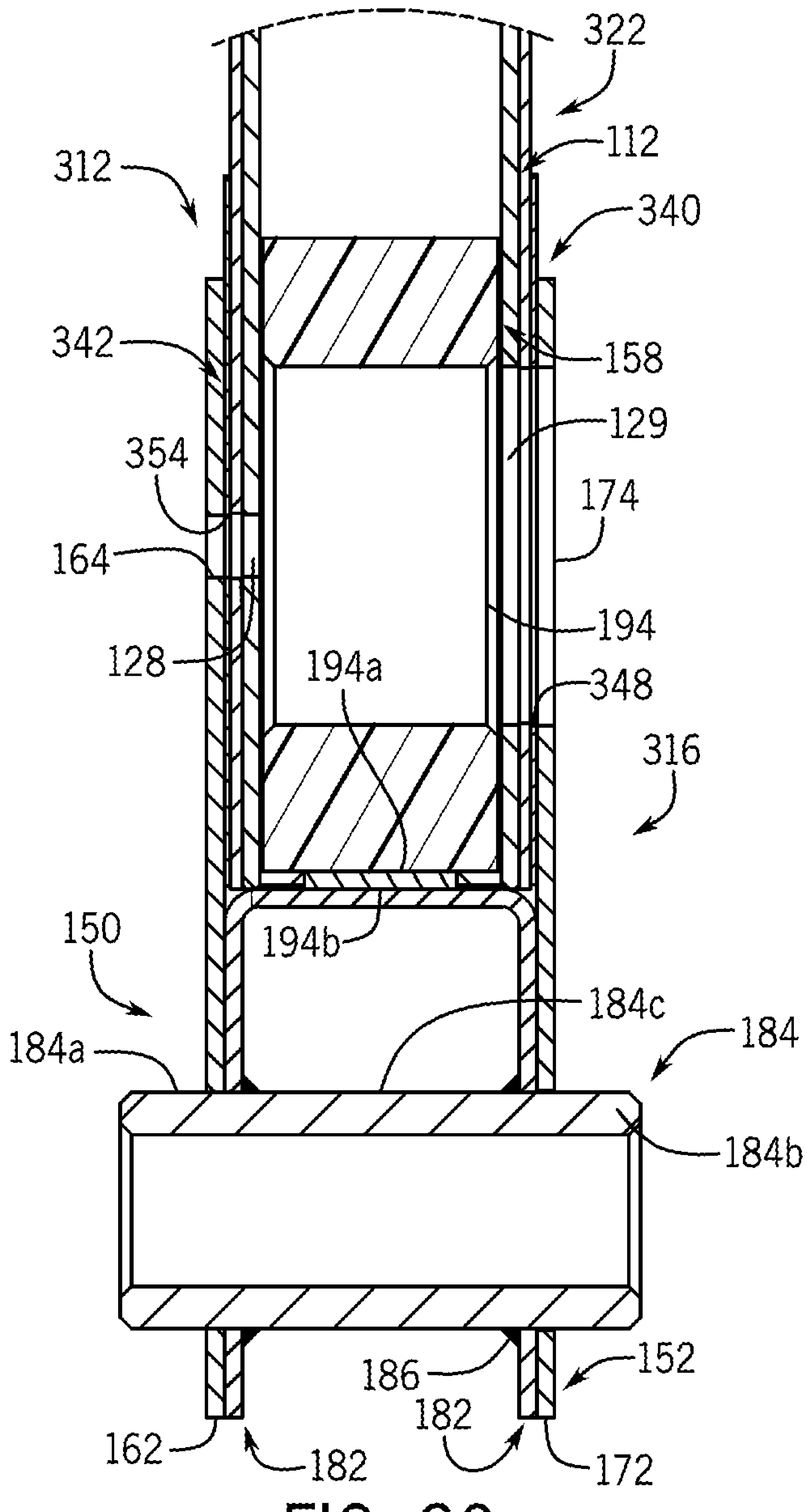
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FIG. 30

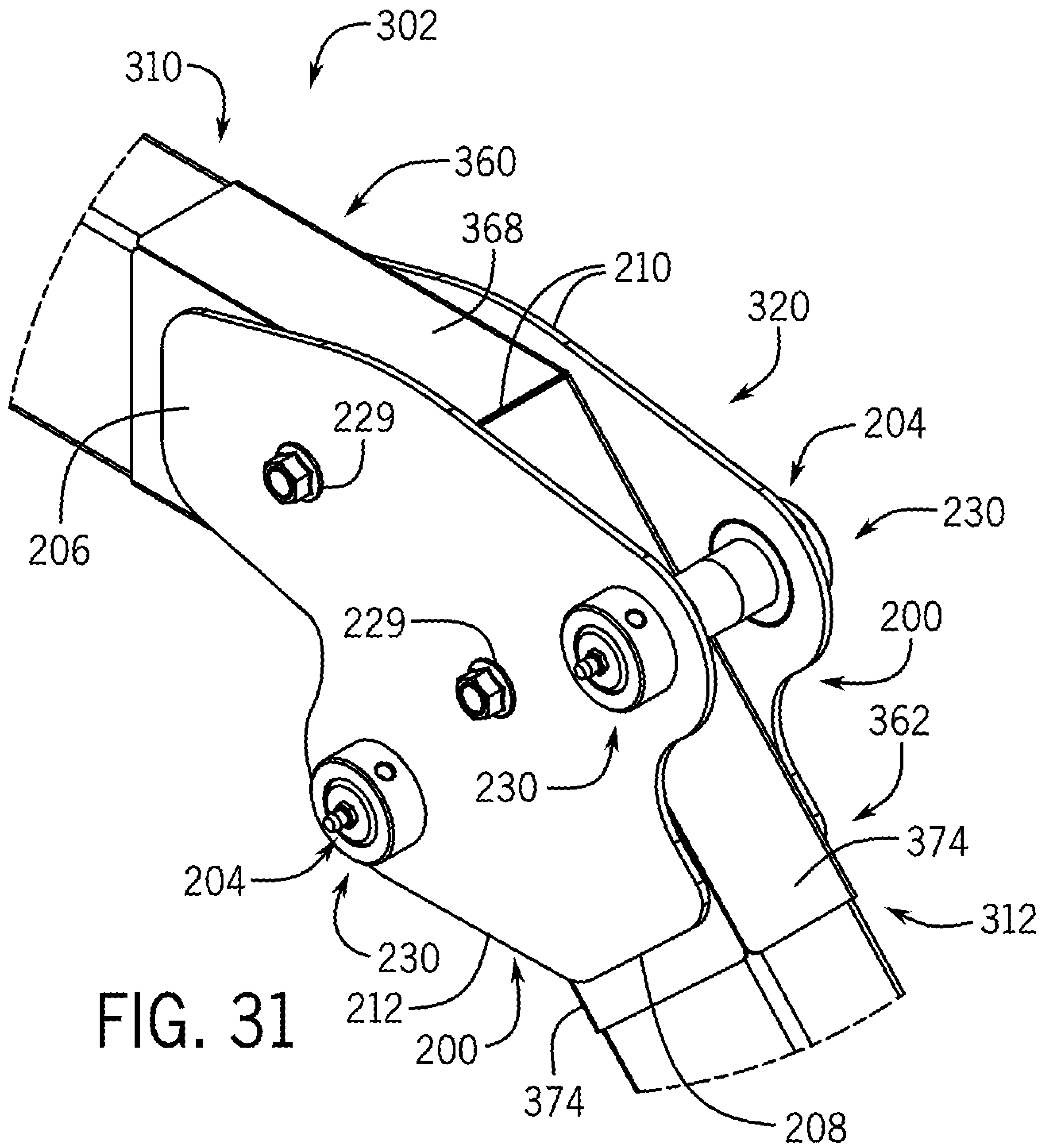

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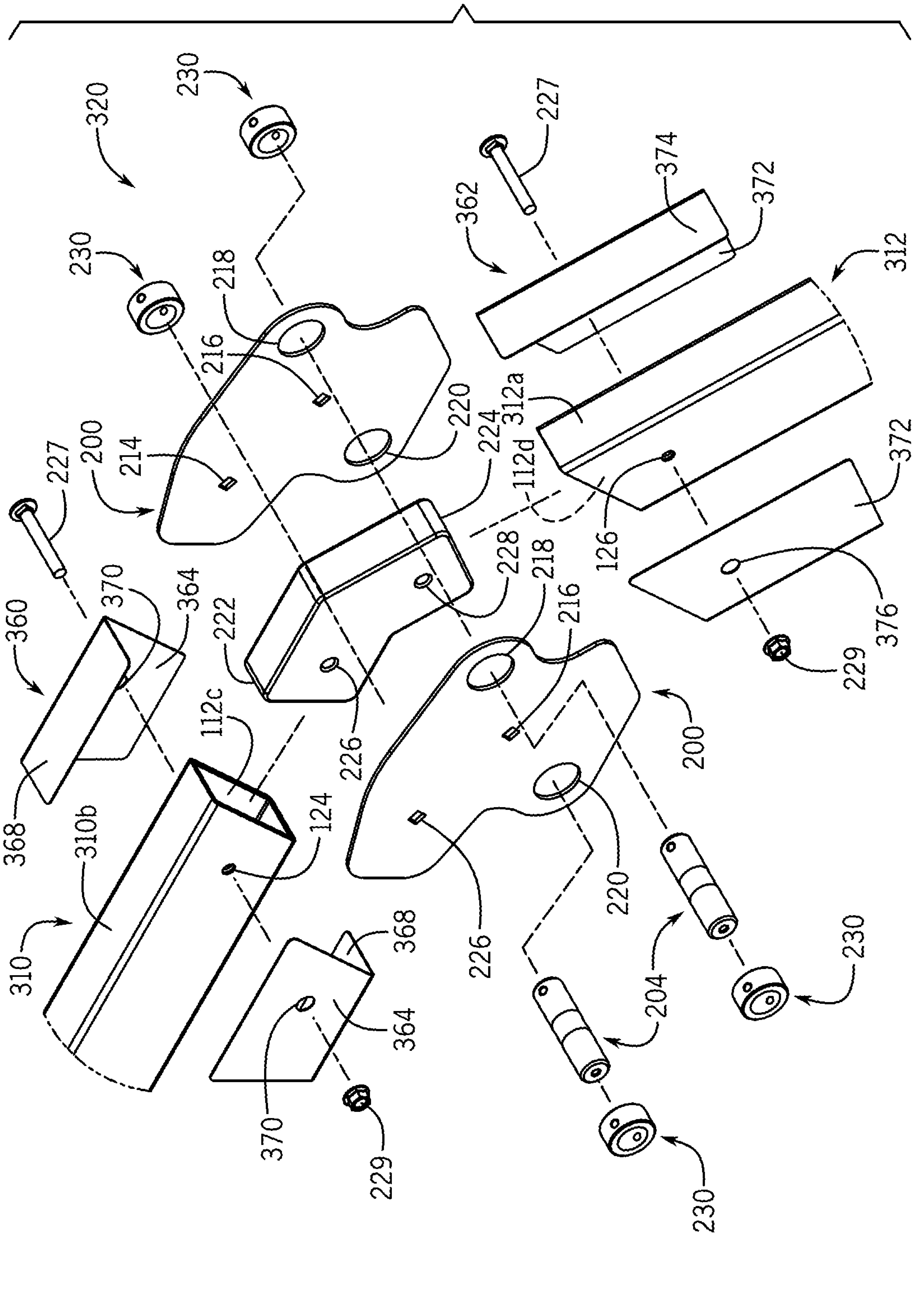
FIG. 31

FIG. 32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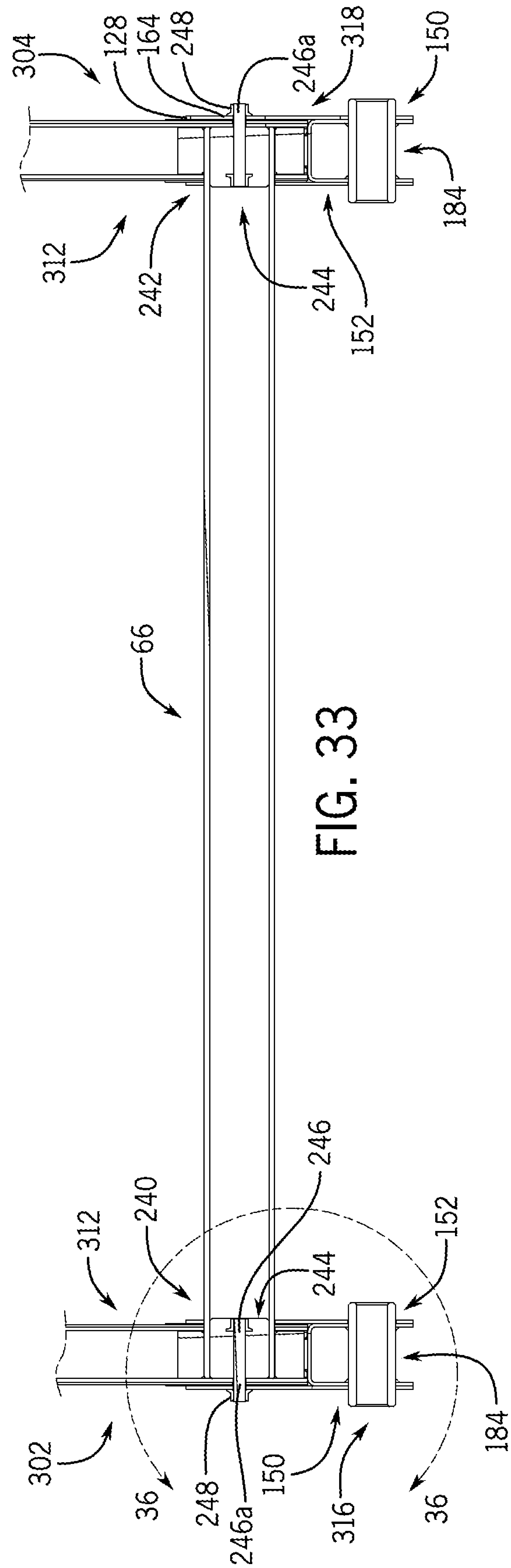
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FIG. 33

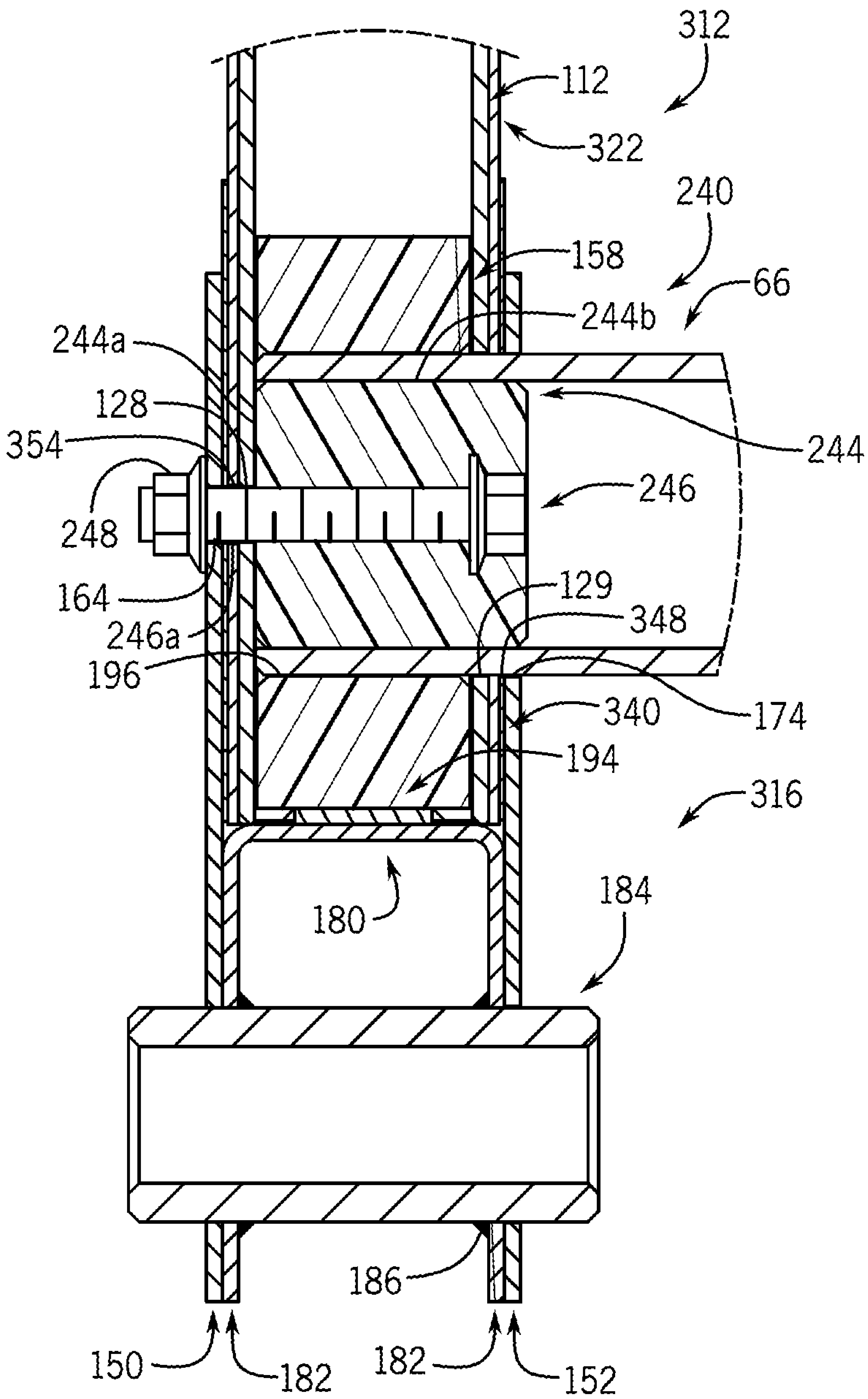
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FIG. 34

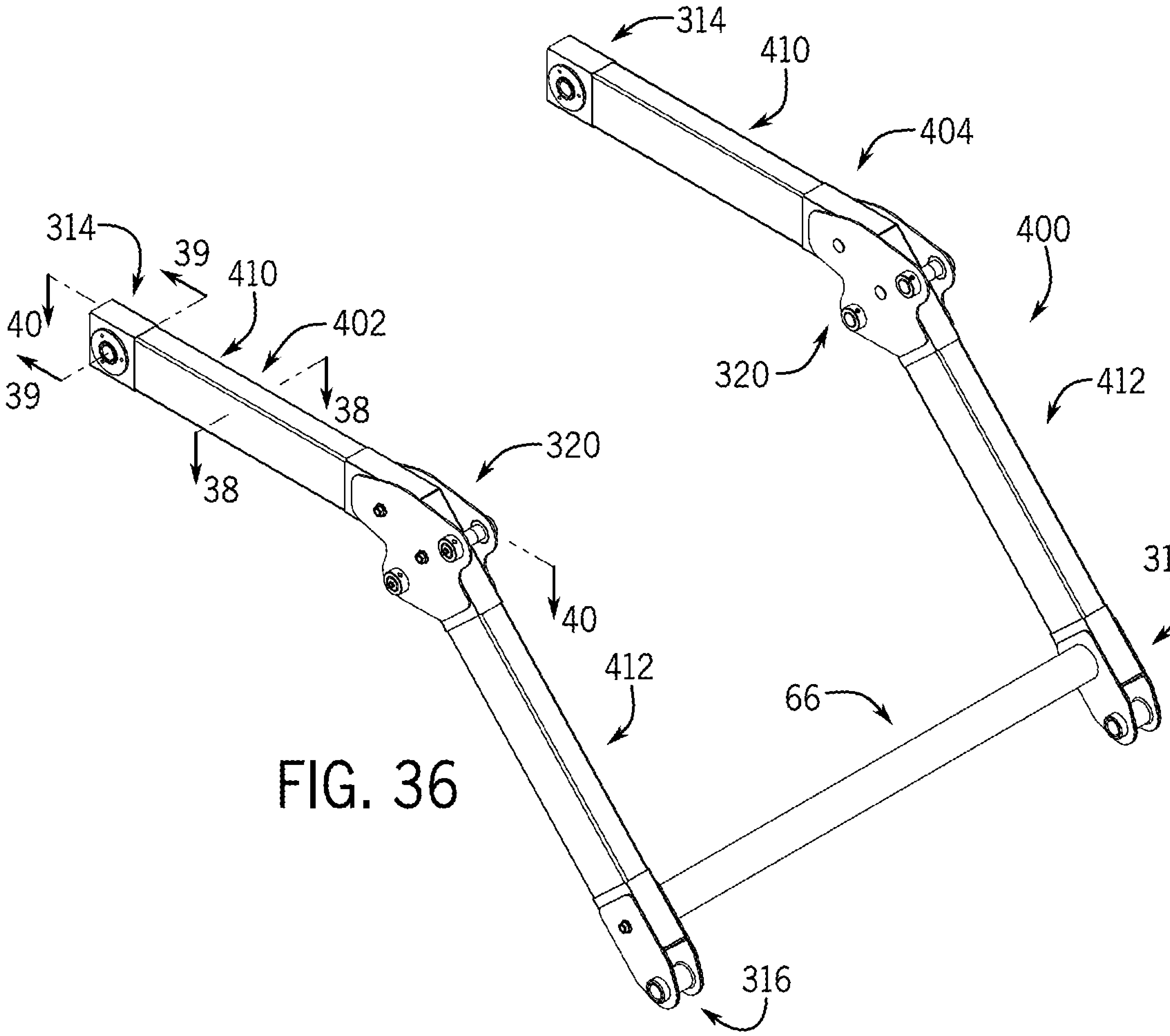
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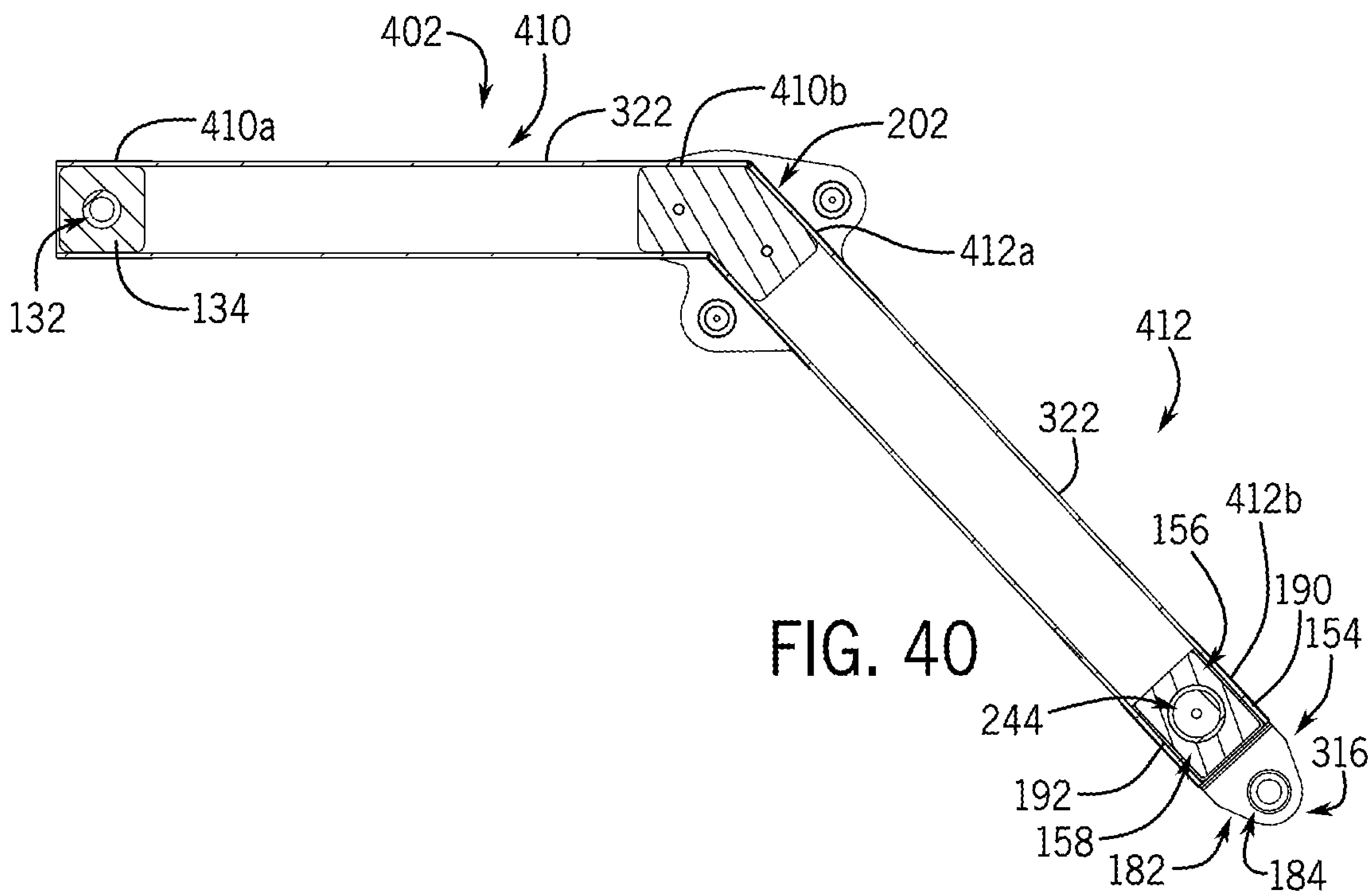
FIG. 36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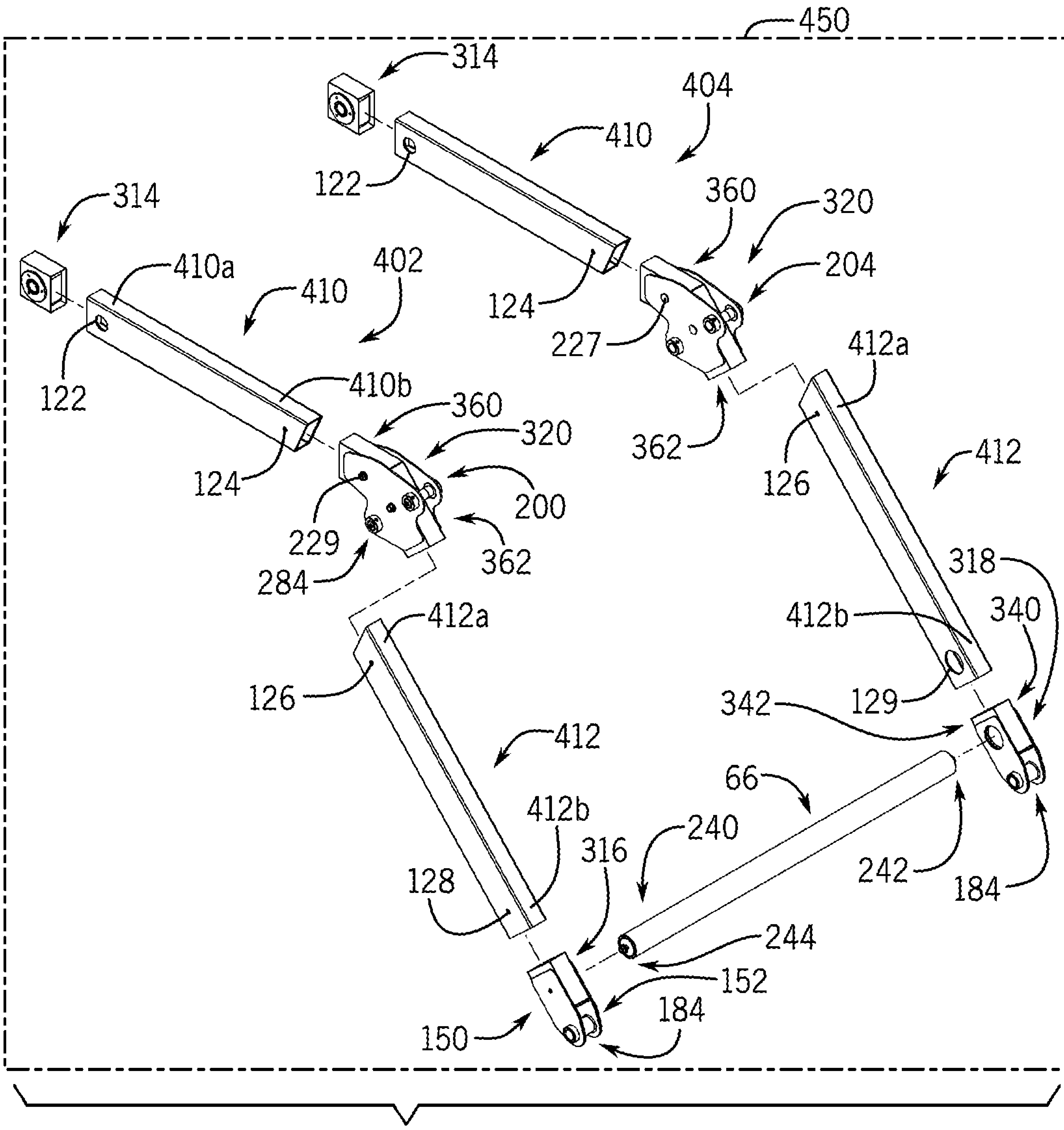
182
184

FIG. 40


450
314
404
410
122
314
360
320
410a
410
402
204
124
227
412a
122
410b
360
320
362
412
124
126
229
200
284
362
318
412a
412b
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126
129
342
412
66
412b
240
316
242
184
128
244
152
184
150

FIG. 37

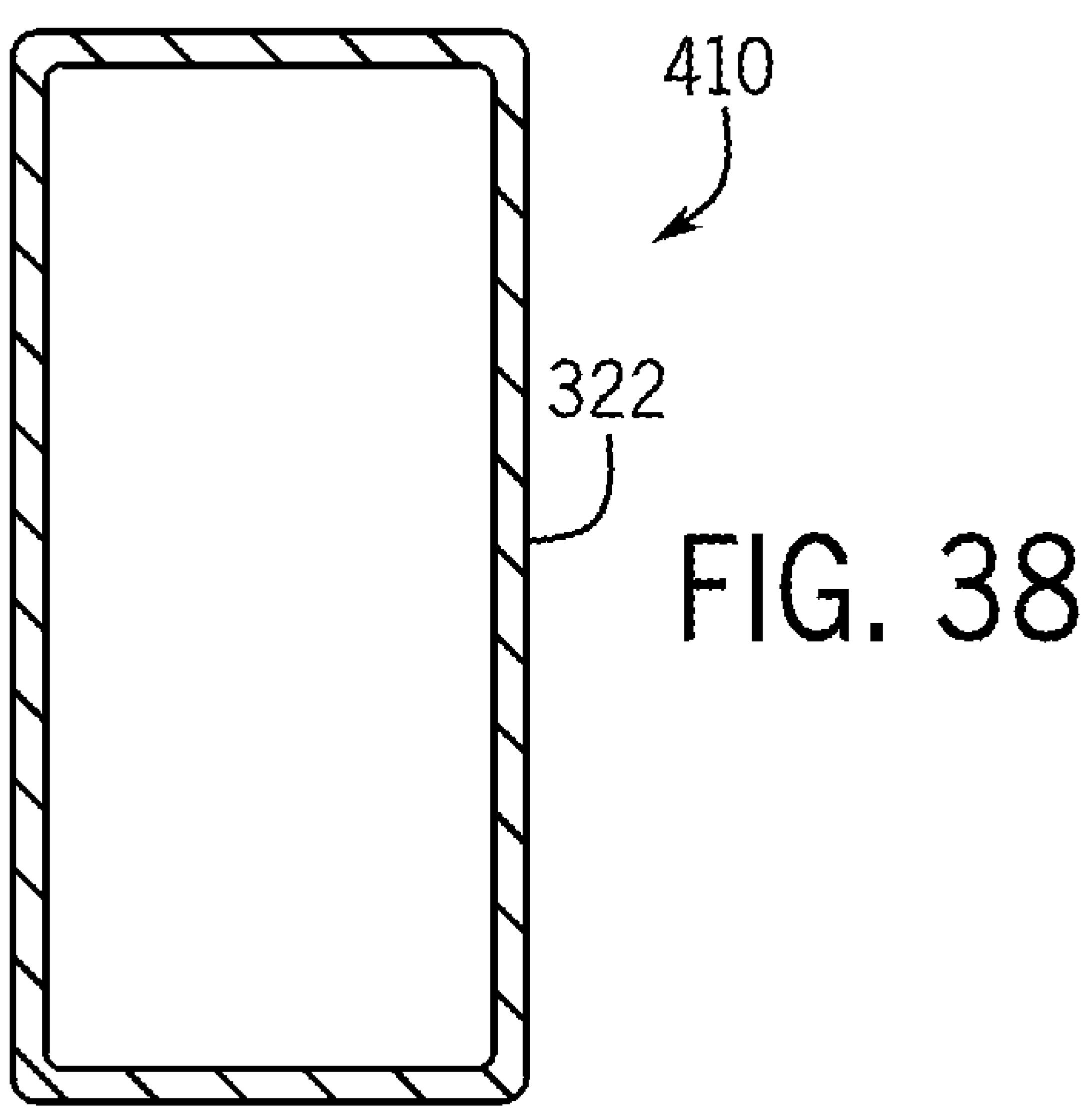
410
322

FIG. 38

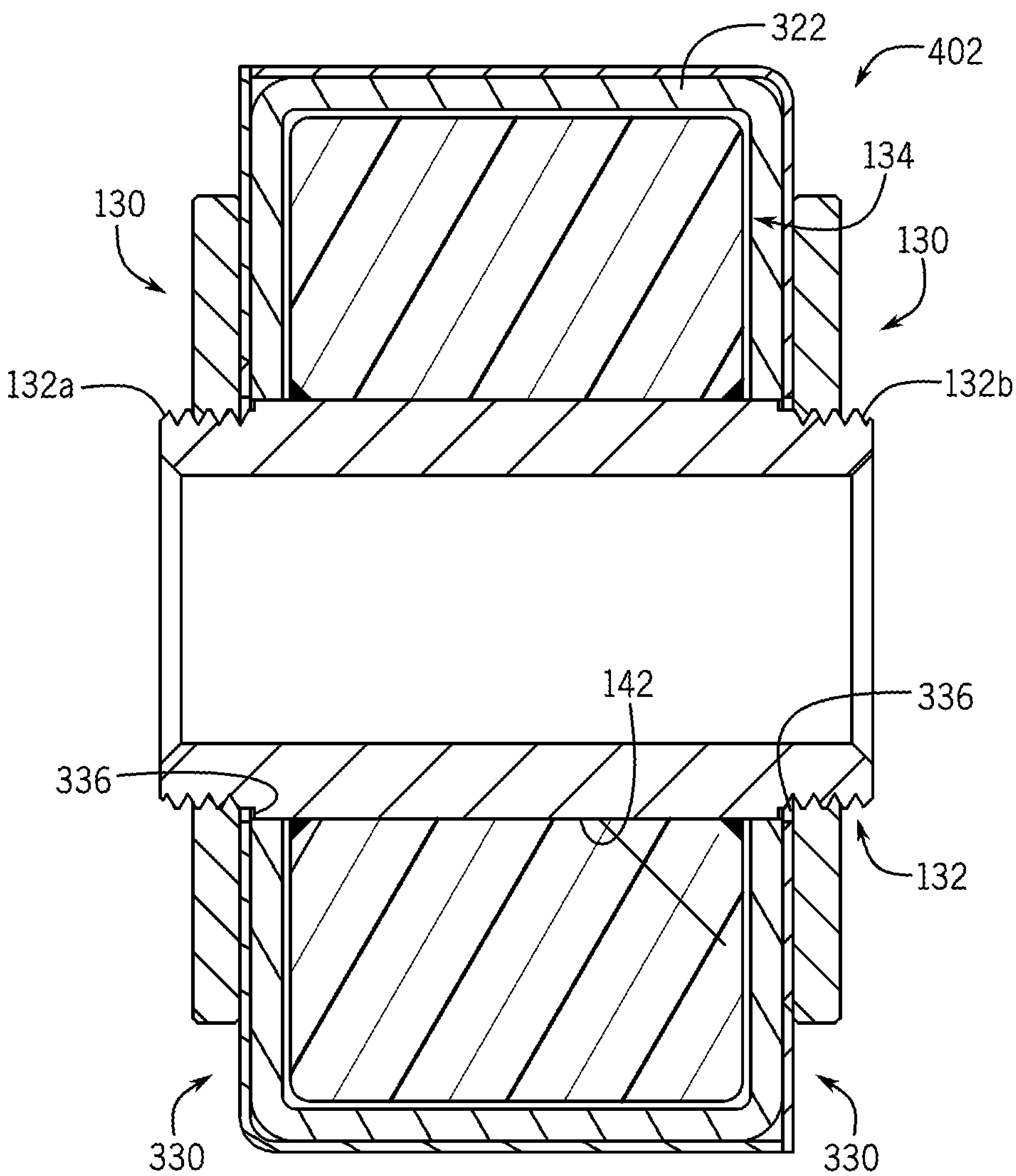

FIG. 39

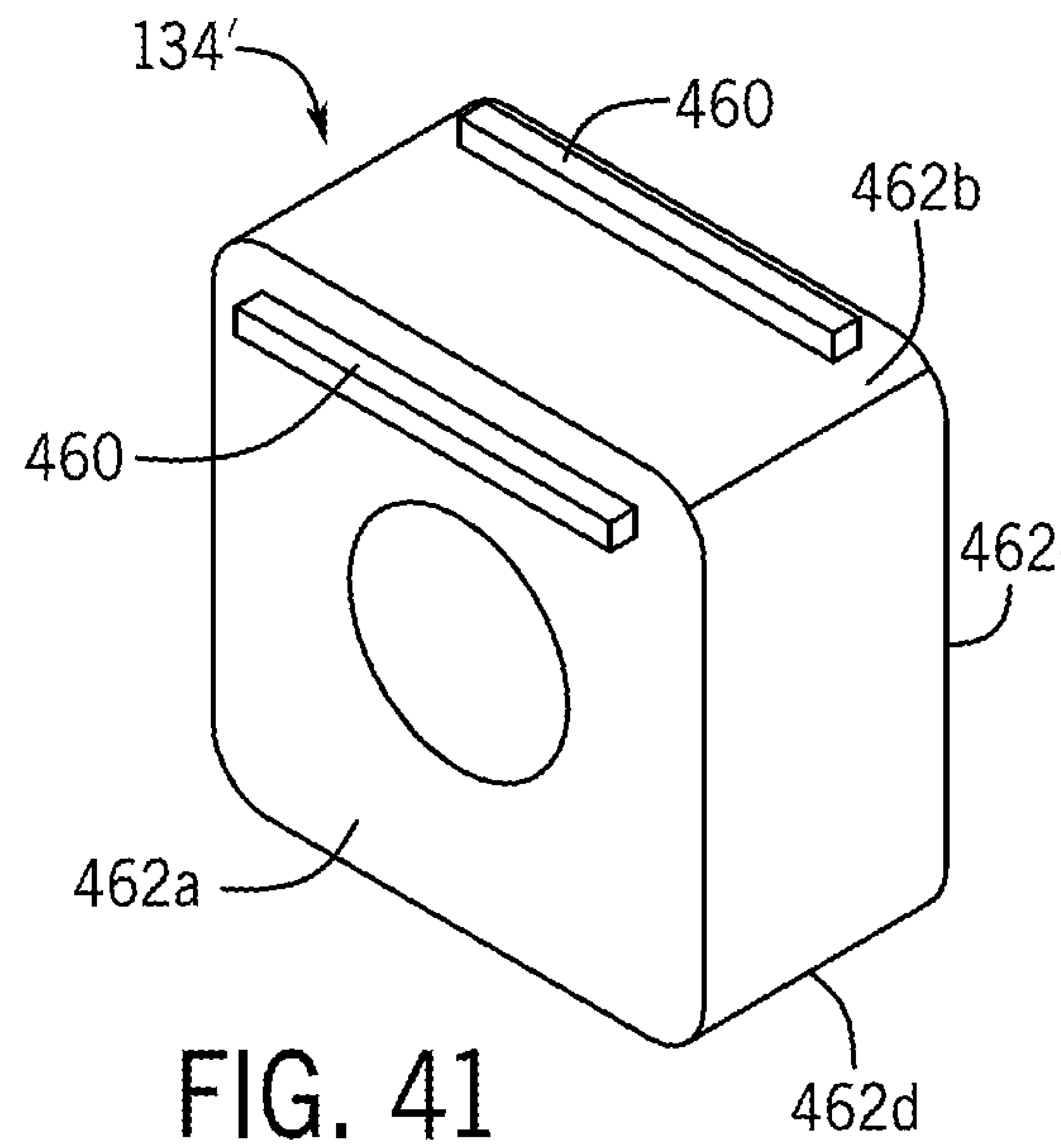

FIG. 41

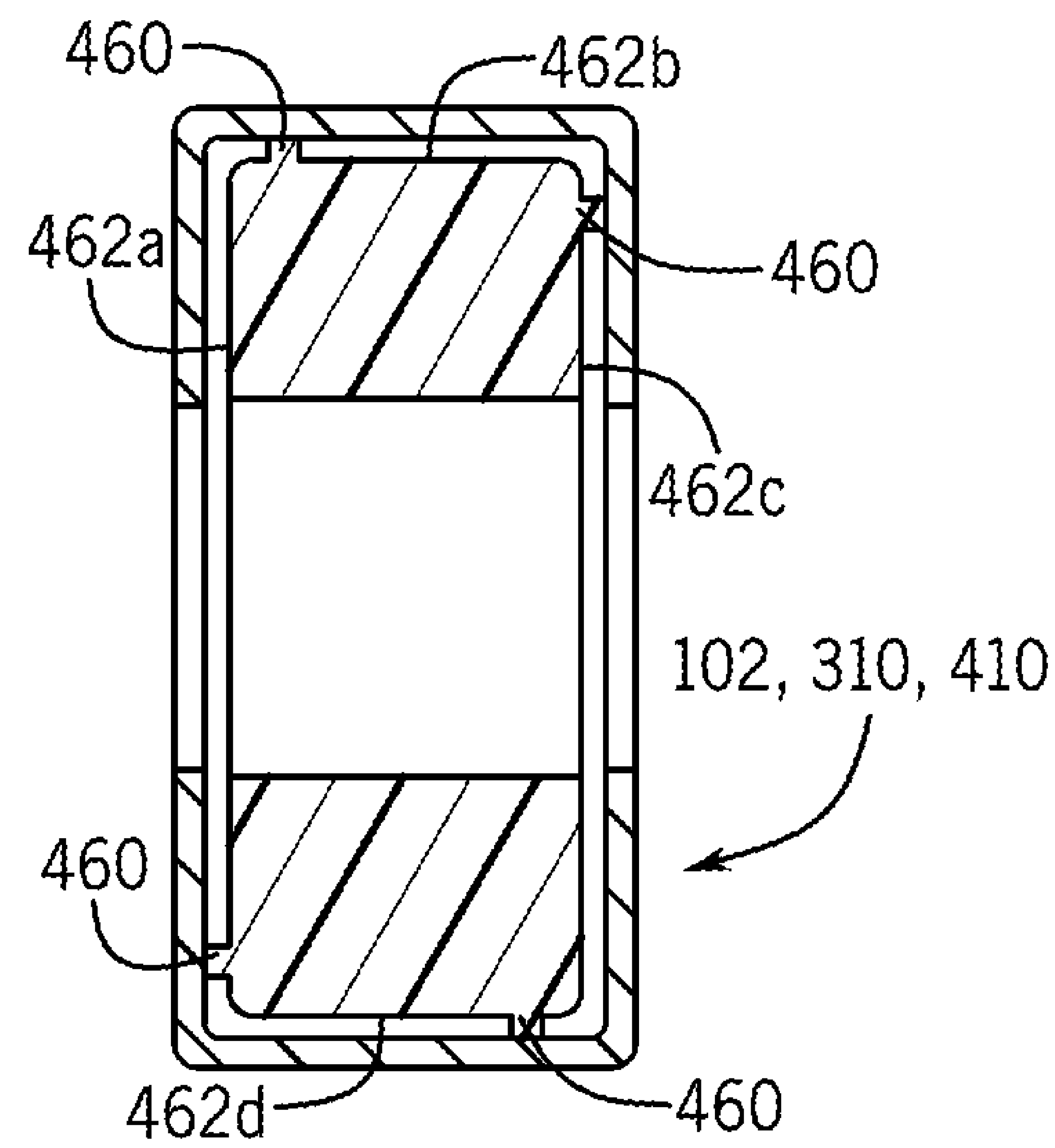

FIG. 42

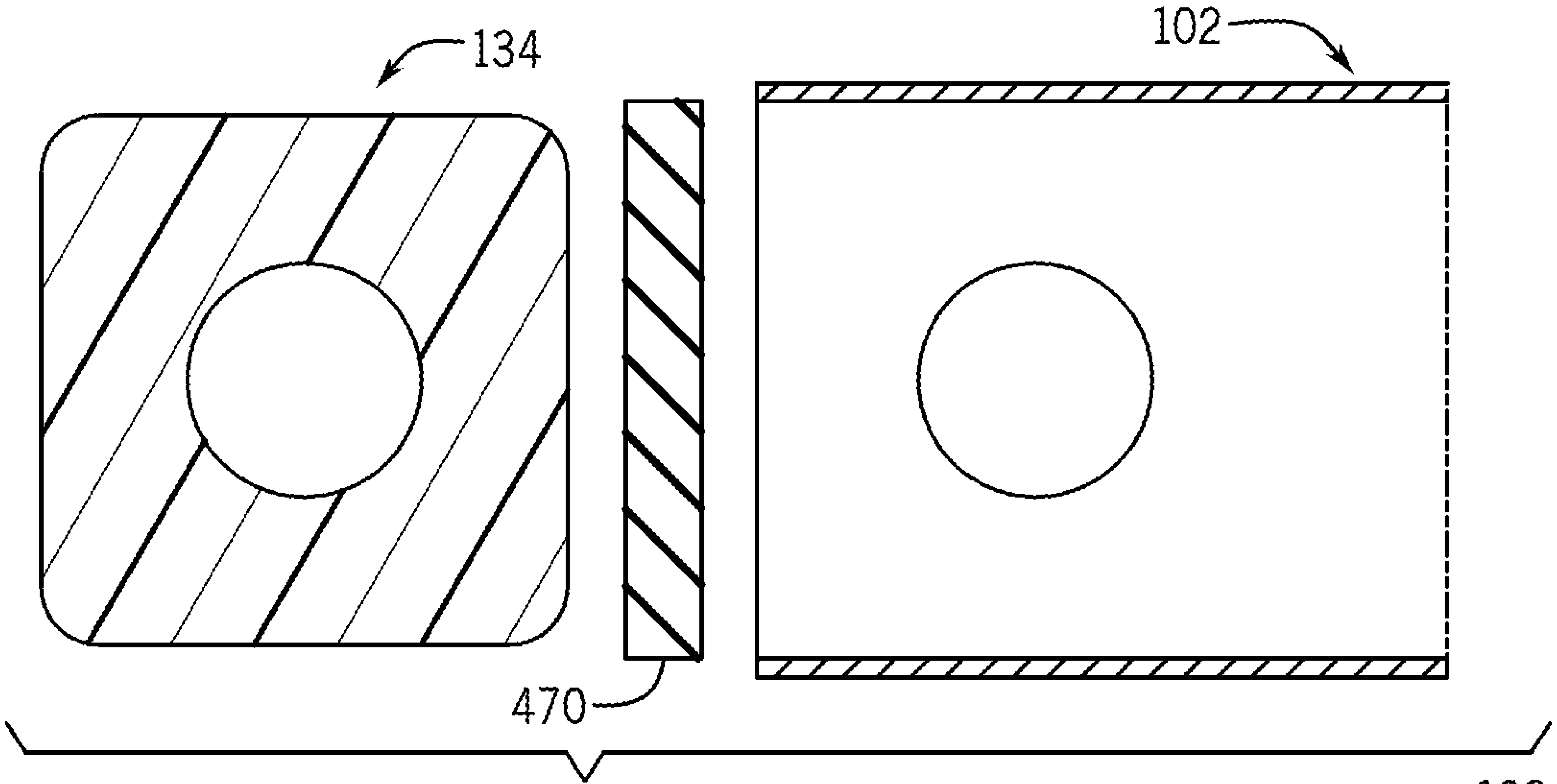

FIG. 43

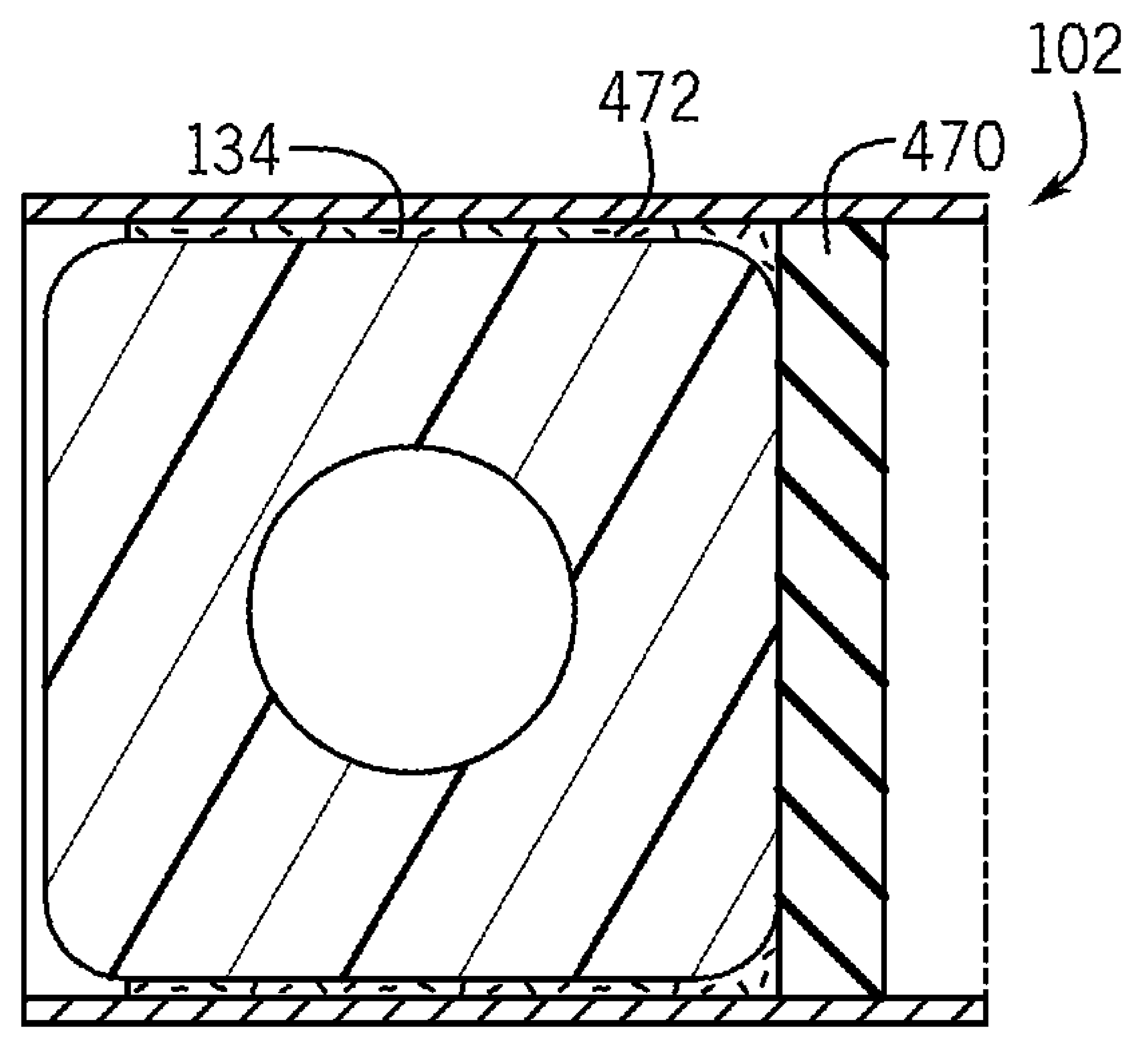

FIG. 44

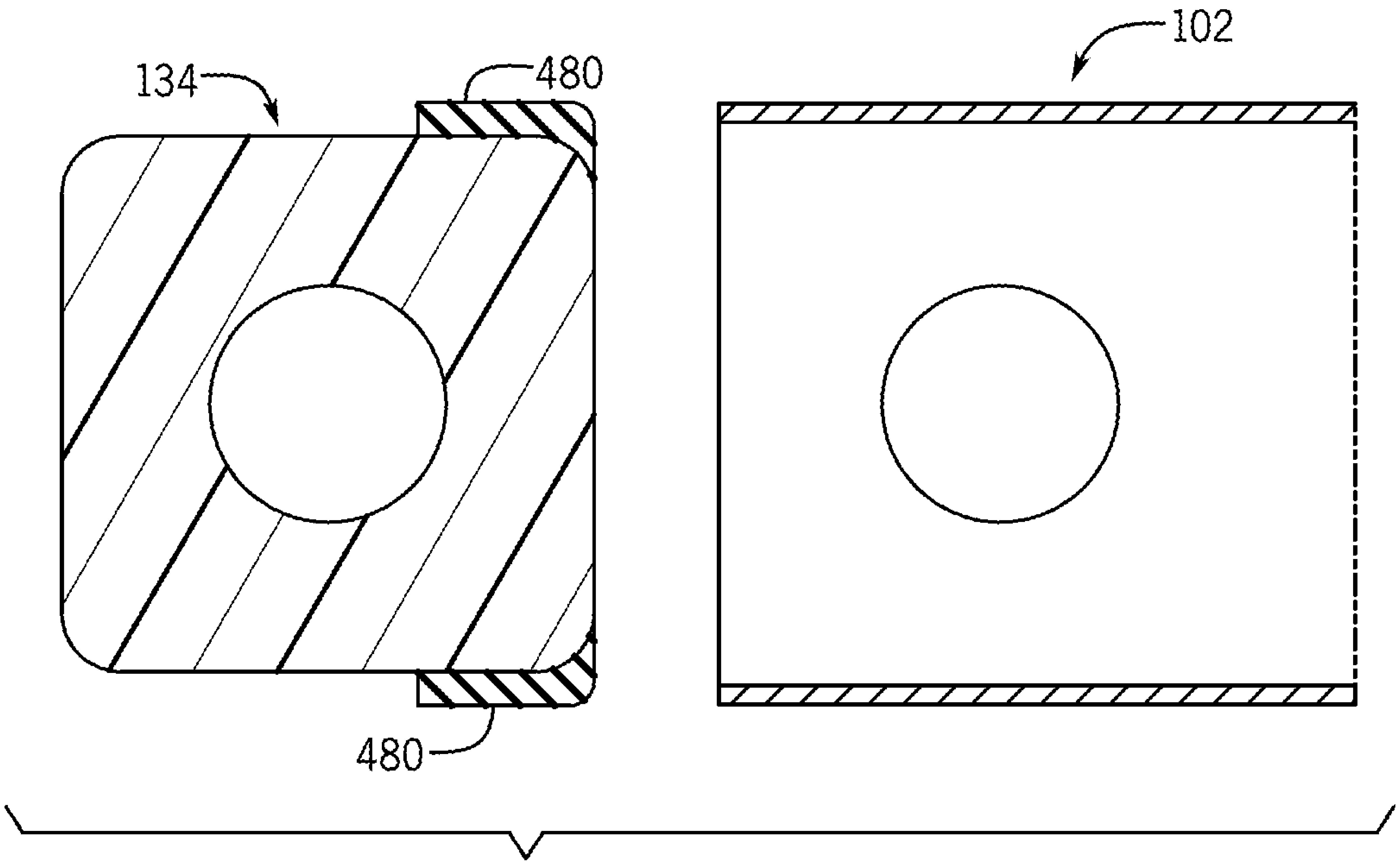

FIG. 45

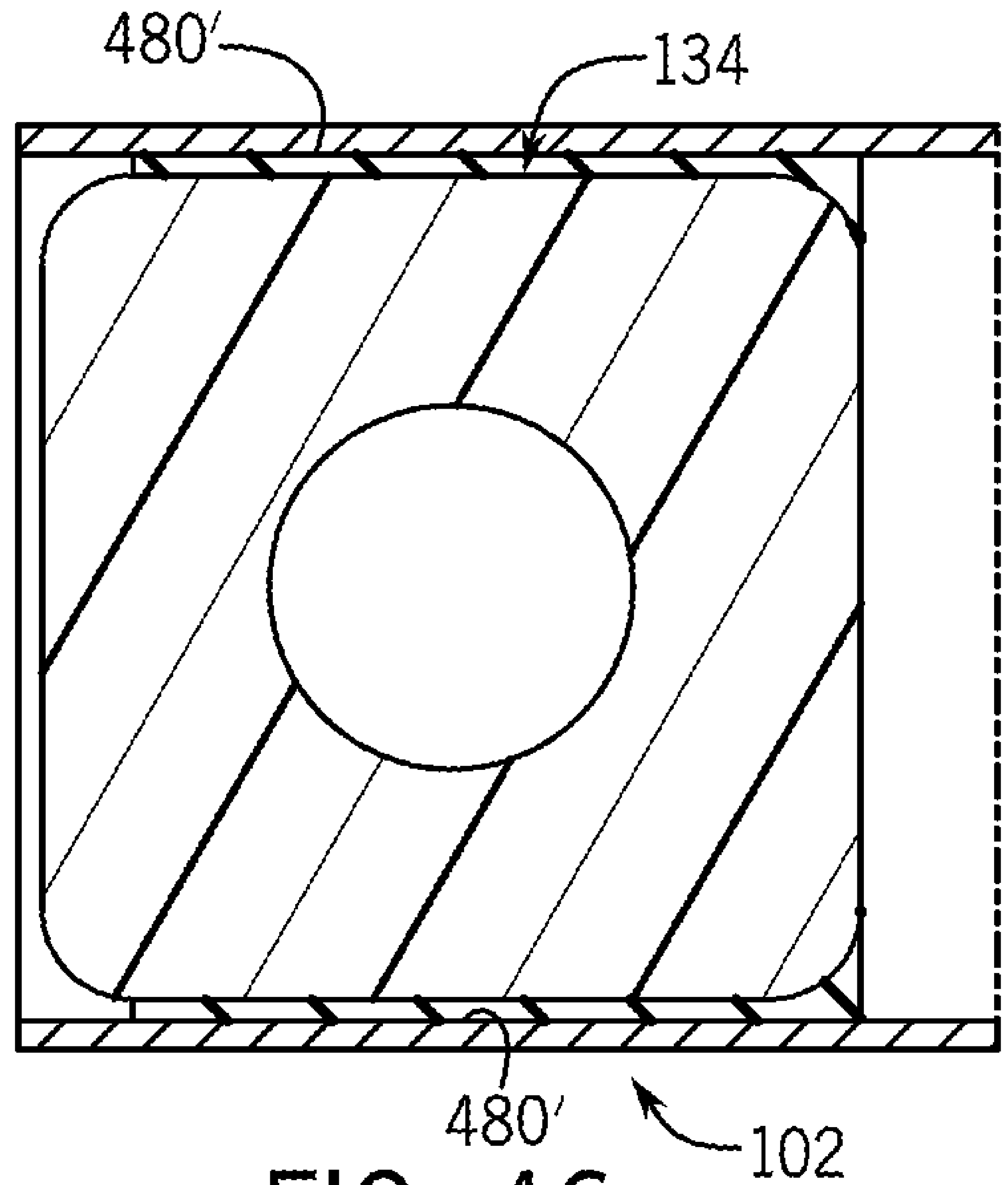

FIG. 46

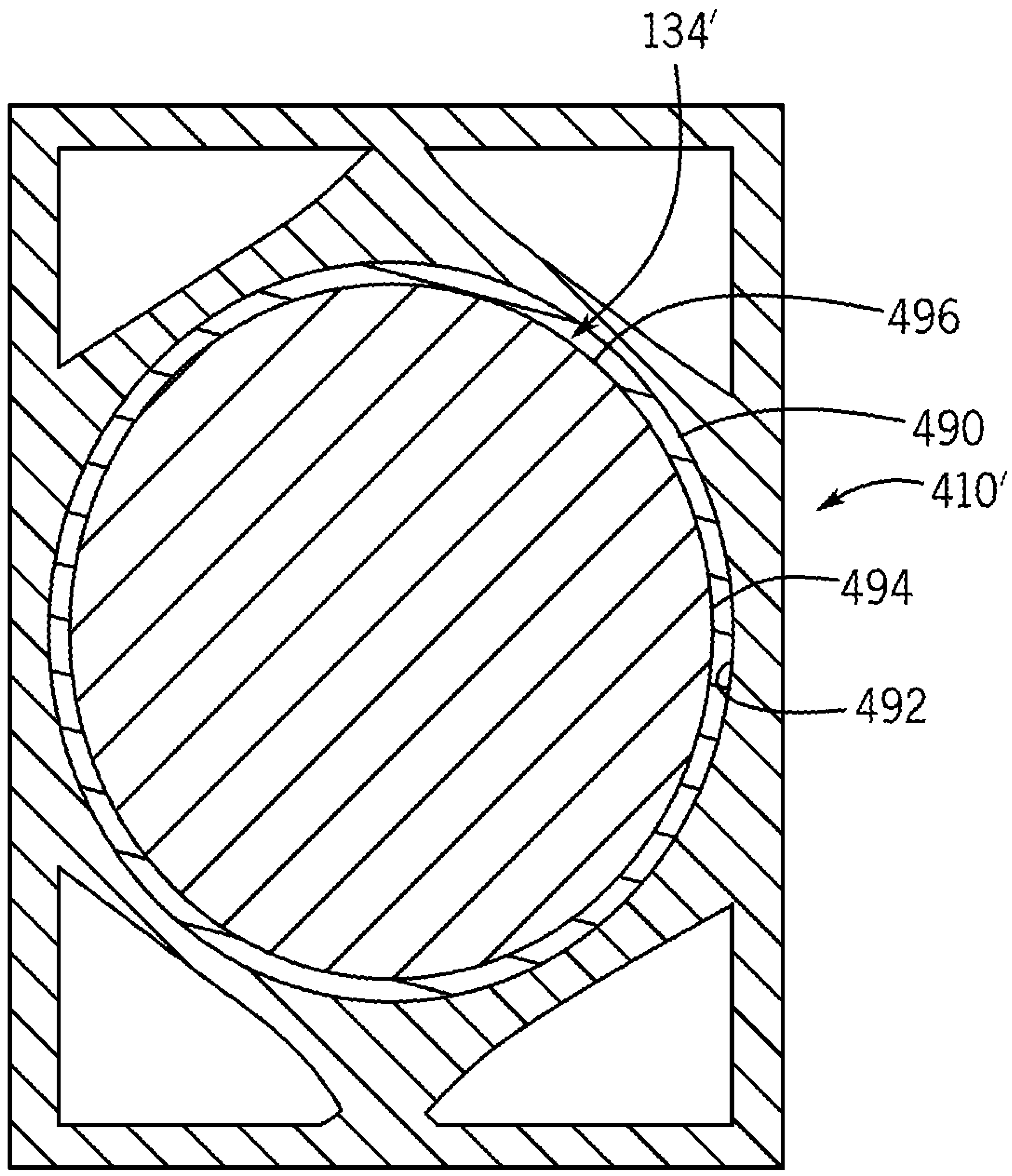

FIG. 47

HYBRID LOADER BOOM ARM ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION(S)

Not applicable.

STATEMENT OF FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

FIELD OF THE DISCLOSURE

This disclosure relates to work vehicles, such as loaders, and boom arm assemblies that are configured to attach a work implement, such as a bucket, to the work vehicles to carry material.

BACKGROUND OF THE DISCLOSURE

In the agriculture, construction and forestry industries, various work machines, such as loaders, may be utilized in lifting and moving various materials. In certain examples, a loader may include a bucket pivotally coupled by a loader boom arms to the vehicle chassis. One or more hydraulic cylinders move the loader boom arms and/or the bucket to move the bucket between positions relative to the chassis to lift and move materials.

Various factors are considered when designing or selecting the loader boom arms and bucket arrangement used, for example, the durability and wear resistance of the loader boom arms, and the weight of material the loader boom arms can lift. These factors typically indicate that the loader boom arms be made of heavy steel plate construction to handle large volumes of material and the corresponding weight and other forces associated with loading and carrying the heavy material. This also requires a robust hydraulic system with correspondingly large-capacity pumps, accumulators, valves and cylinders. Further, wear or damage to the loader boom arms may also require replacement or vehicle downtime to repair the heavy-duty components.

SUMMARY OF THE DISCLOSURE

The disclosure provides a hybrid loader boom arm assembly in which an arm assembly and a second arm assembly formed of a lightweight material are interconnected by a torque transfer tube formed of a lightweight material.

In one aspect, the disclosure provides a hybrid loader boom arm assembly kit for a loader work vehicle. The kit includes a hollow first beam formed from a lightweight material, and a block formed from a second lightweight material. The block is configured to couple within the first beam. The kit includes at least one first steel reinforcing plate configured to couple to the first beam at the end, and at least one connecting plate configured to couple to the at least one first reinforcing plate.

In another aspect, the present disclosure provides a method of assembling a hybrid loader boom arm for a loader work vehicle. The method includes coupling a first beam formed from a lightweight material to a first block formed from a second lightweight material. The method includes coupling at least one first steel reinforcing plate to the first beam at an end of the first beam, and coupling at least one connecting plate to the at least one first reinforcing plate.

In yet another aspect, the present disclosure provides a method of assembling a hybrid loader boom arm for a loader work vehicle. The method includes coupling a first beam formed from a lightweight material to a second beam formed from the lightweight material with a first block formed from a second lightweight material to form an arm assembly. The method includes coupling at least one first steel reinforcing plate to the first beam at an end of the first beam, and coupling at least one second steel reinforcing plate to the second beam at a second end of the second beam. The method includes coupling at least one connecting plate to the at least one first reinforcing plate and the at least one second reinforcing plate.

The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an example work vehicle in the form of an agricultural loader in which the disclosed hybrid loader boom arm assembly may be used;

FIG. **1**A is a perspective view of an example work vehicle in the form of a compact utility tractor in which the disclosed hybrid loader boom arm assembly may be used;

FIG. **2** is a side view of an example hybrid loader boom arm assembly coupled to a bucket as shown in FIG. **1**;

FIG. **3** is a perspective view of the hybrid loader boom arm assembly of FIG. **2**;

FIG. **4** is an exploded view of a first beam of one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **5** is a partially exploded view of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **6** is a detail view of a vehicle mounting subassembly coupled to the first beam of one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **7** is an exploded view of the vehicle mounting subassembly of FIG. **6**;

FIG. **8** is a cross-sectional view of the vehicle mounting subassembly, taken along line **8-8** of FIG. **6**;

FIG. **9** is a detail view of a bucket mount bracket subassembly coupled to a second beam of an arm assembly of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **10** is an exploded view of the bucket mount bracket subassembly of FIG. **9**;

FIG. **11** is a cross-sectional view of the bucket mount bracket subassembly, taken along line **11-11** of FIG. **9**;

FIG. **12** is a cross-sectional view of the bucket mount bracket subassembly, taken along line **12-12** of FIG. **9**;

ii [**0024**] FIG. **13** is a detail view of a knee mounting subassembly of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **14** is an exploded view of the knee mounting subassembly of FIG. **13**;

FIG. **11** is a cross-sectional view of the bucket mount bracket subassembly, taken along line **11-11** of FIG. **9**;

FIG. **15** is a cross-sectional view of one arm assembly of the hybrid loader boom arm assembly, taken along line **15-15** of FIG. **3**;

FIG. **16** is a cross-sectional view of a torque transfer tube connected to the arm assembly and a second arm assembly of the hybrid loader boom arm assembly, taken along line **16-16** of FIG. **3**;

FIG. **17** is a perspective view of an end of the torque transfer tube of the hybrid loader boom arm assembly of FIG. **3**;

FIG. **18** is an exploded view of the end of the torque transfer tube of the hybrid loader boom arm assembly of FIG. **17**;

FIG. **19** is a detail cross-sectional view of the end of the torque transfer tube connected to the arm assembly of the hybrid loader boom arm assembly, taken at **19** of FIG. **16**;

FIG. **20** is a perspective view of another hybrid loader boom arm assembly for use with the work vehicle of FIG. **1** or FIG. **1**A;

FIG. **21** is an exploded view of a first beam of one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **20**;

FIG. **22** is a cross-sectional view of the first beam of the one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **20**, taken along line **22-22** of FIG. **20**;

FIG. **23** is a partially exploded view of the hybrid loader boom arm assembly of FIG. **20**;

FIG. **24** is a detail view of a vehicle mounting subassembly coupled to the first beam of one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **20**;

FIG. **25** is an exploded view of the vehicle mounting subassembly of FIG. **24**;

FIG. **26** is a cross-sectional view of the vehicle mounting subassembly, taken along line **26-26** of FIG. **24**;

FIG. **27** is a detail view of a bucket mount bracket subassembly of the hybrid loader boom arm assembly of FIG. **20**;

FIG. **28** is an exploded view of the bucket mount bracket subassembly of FIG. **27**;

FIG. **29** is a cross-sectional view of the bucket mount bracket subassembly, taken along line **29-29** of FIG. **27**;

FIG. **30** is a cross-sectional view of the bucket mount bracket subassembly, taken along line **30-30** of FIG. **27**;

FIG. **31** is a detail view of a knee mounting subassembly of the hybrid loader boom arm assembly of FIG. **20**;

FIG. **32** is an exploded view of the knee mounting subassembly of FIG. **31**;

FIG. **33** is a cross-sectional view of a torque transfer tube connected to the arm assembly and a second arm assembly of the hybrid loader boom arm assembly, taken along line **33-33** of FIG. **20**;

FIG. **34** is a detail cross-sectional view of the end of the torque transfer tube connected to the arm assembly of the hybrid loader boom arm assembly, taken at **34** of FIG. **20**;

FIG. **35** is a cross-sectional view of one arm assembly of the hybrid loader boom arm assembly, taken along line **35-35** of FIG. **20**;

FIG. **36** is a perspective view of another hybrid loader boom arm assembly for use with the work vehicle of FIG. **1** or FIG. **1**A;

FIG. **37** is a partially exploded view of the hybrid loader boom arm assembly of FIG. **36**;

FIG. **38** is a cross-sectional view of the first beam of the one of the arm assemblies of the hybrid loader boom arm assembly of FIG. **36**, taken along line **38-38** of FIG. **36**;

FIG. **39** is a cross-sectional view of the vehicle mounting subassembly, taken along line **39-39** of FIG. **36**;

FIG. **40** is a cross-sectional view of one arm assembly of the hybrid loader boom arm assembly, taken along line **40-40** of FIG. **36**;

FIG. **41** is a perspective view of an example block having at least one rib for use with one of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36** in accordance with various embodiments;

FIG. **42** is a cross-sectional schematic view that illustrates the block of FIG. **41** positioned within a first beam of one of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36** in accordance with various embodiments;

FIG. **43** is a partially exploded cross-sectional schematic view that illustrates an insert for use with coupling a block to one of the first beams of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36** in accordance with various embodiments;

FIG. **44** is a cross-sectional schematic view that illustrates the block coupled to the first beam with an adhesive that is retained by the insert;

FIG. **45** is a partially exploded cross-sectional schematic view that illustrates an energy activated foam for use with coupling a block to one of the first beams of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36** in accordance with various embodiments;

FIG. **46** is a cross-sectional schematic view that illustrates the energy activated foam of FIG. **45** in an activated state to couple the block to the first beam; and

FIG. **47** is a cross-sectional schematic view of an example cross-section for one of the first beams and/or the second beams of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36**, and an example cross-section for one of the blocks of the hybrid loader boom arm assemblies of FIG. **1**, **20** or **36**.

Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

The following describes one or more example embodiments of the disclosed hybrid loader boom arm assembly, as shown in the accompanying figures of the drawings described briefly above. Various modifications to the example embodiments may be contemplated by one of skill in the art.

As used herein, unless otherwise limited or modified, lists with elements that are separated by conjunctive terms (e.g., "and") and that are also preceded by the phrase "one or more of" or "at least one of" indicate configurations or arrangements that potentially include individual elements of the list, or any combination thereof. For example, "at least one of A, B, and C" or "one or more of A, B, and C" indicates the possibilities of only A, only B, only C, or any combination of two or more of A, B, and C (e.g., A and B; B and C; A and C; or A, B, and C).

Conventional loader boom arms for use in various construction and agricultural applications to couple a work implement to a work vehicle for hauling materials (e.g., dirt, sand, aggregate and so on) are typically cast or fabricated of heavy-duty construction using high-strength materials (e.g., steel). The heavy-duty construction affords conventional loader boom arms the ability to undergo extreme lifting and treatment during use. In addition to the material itself, the weight of the heavy-duty loader boom arms must be accommodated by the host machine, and specifically by its hydraulic system, to ensure that the machine performs as expected, that is will raise and lower the loader boom arms at the rate and range of motion desired. Further, as heavy and rugged as they are, encountering sufficient loading, abrasion or other forces can cause damage to conventional loader boom arms. The loader boom arms may yield (i.e., crack) due to impact or stress concentrations, or they may experience wear that may impact the performance of the machine. Damage or worn loader boom arms may need to be replaced or repaired at significant expense or operational downtime of the machine.

This disclosure provides an alternative to the conventional loader boom arms through the use of a hybrid loader boom arm assembly that is configured to couple to the work vehicle and the bucket. The disclosed hybrid loader boom arm assembly has a light-duty construction, and is composed of generally lightweight materials. For example, the disclosed hybrid loader boom arm assembly ("HLBAA") may have arm assemblies composed of a first beam, a second beam and a torque transfer tube, each of which is composed of a lightweight material. As used herein "lightweight material" generally denotes a material that has a density that is less than a density of steel, such that an arm assembly of the HLBAA has a density that is less than a density of a conventional steel arm assembly. Exemplary lightweight materials include, but are not limited to, aluminum, polymer-based material, glass-fiber reinforced polymer-based materials, carbon-fiber reinforced polymer-based materials, G10 material, and the like. In certain embodiments, internal fibrous reinforcements may be employed to enable the polymer-based material, glass-fiber reinforced polymer-based materials and carbon-fiber reinforced polymer-based materials to sustain the loading and twisting experienced during the operation of the loader. The internal fibrous reinforcements may be randomly oriented or may be oriented in the direction of loading. The internal fibrous reinforcements include, but are not limited to, glass, basalt, carbon, aramids, olefins, and cellulose-based materials. The HLBAA generally has a weight that is about 10% to about 20% lighter than conventional steel loader boom arms. This reduces fuel consumption, and may enable the use of a light-duty hydraulic system. In this way, the disclosed HLBAA may have both lightweight and low-cost attributes.

In addition, the first beam, the second beam and the torque transfer tube that make up the HBLAA may be coupled together using various joining techniques, including the use of an adhesive and adhesive bonds. The adhesive used with the HBLAA may include, but is not limited to, a polyurethane-based adhesive, epoxy, etc. Generally, the lightweight construction of the HBLAA enables the HBLAA to be packaged in regular packaging, and transported in a disassembled state, which reduces shipping and transportation costs. The HBLAA may be assembled at the customer's location or other location remote from the manufacturing facility, which increases a volume of HBLAA that may be transported in a transportation vehicle, for example. The HBLAA may be shipped as a kit and bonded at the customer's location, or assembled in the factory and shipped to the customer. As used herein, the adhesives to form the adhesive bond of the HBLAA cure at room temperature and do not require special equipment to cure or assemble, which enables a customer, remote from the factory, to assemble the HBLAA. Moreover, the adhesive bonds are formed by adhesives that will break apart when exposed to a specific energy source, such as through inductive heating. This enables the customer to disassemble the HBLAA for repair or replacement of a damaged component. Further, in certain instances, the customer may be provided with a structural reinforcing patch, which the customer may adhesively bond or fasten to the damaged area to repair the HBLAA, without requiring disassembly of the HBLAA.

The following describes one or more example implementations of the disclosed HLBAA. The HLBAA may be utilized with various machines or work vehicles, including loaders and other machines for lifting and moving various materials in the agricultural and construction industries. Referring to FIGS. **1** and **2**, in some embodiments, the HLBAA may be used with an agricultural loader **10**. It will be understood that the configuration of the loader **10** is presented as an example only. In this regard, the disclosed HLBAA may be implemented as a front loader removably coupled to a work vehicle, such as a tractor. Other work vehicles, such as dedicated wheel loaders used in the construction industry, may benefit from the disclosed HLBAA as well. Further, the HLBAA may be used with a skid-steer or other work vehicles that employ one or more boom arms to couple work implements to the work vehicle.

Generally, the loader **10** includes a source of propulsion, such as an engine **12** that supplies power to a transmission **14**. In one example, the engine **12** is an internal combustion engine, such as a diesel engine, that is controlled by an engine control module. The transmission **14** transfers power from the engine **12** to a suitable driveline coupled to one or more driven wheels **16** of the loader **10** to enable the loader **10** to move. The engine **12**, the transmission **14** and the rest of the driveline are supported by a vehicle chassis **18**, which is supported off the ground by the wheels **16**. As is known to one skilled in the art, the transmission **14** can include a suitable gear transmission, which can be operated in a variety of ranges containing one or more gears, including, but not limited to a park range, a neutral range, a reverse range, a drive range, a low range, a high range, etc. The transmission **14** may be controlled by a transmission control module, which is, along with the engine control module, in communication with a master controller **22** (or group of controllers).

The controller **22** may control various aspects of the operation of the loader **10** and may be configured as a computing device with associated processor devices and memory architectures, as a hard-wired computing circuit (or circuits), as a programmable circuit, as a hydraulic, electrical or electro-hydraulic controller, or otherwise. As such, the controller **22** may be configured to execute various computational and control functionality with respect to the loader **10** (or other machinery). In some embodiments, the controller **22** may be configured to receive input signals in various formats (e.g., as hydraulic signals, voltage signals, current signals, and so on), and to output command signals in various formats (e.g., as hydraulic signals, voltage signals, current signals, mechanical movements, and so on). In some embodiments, the controller **22** (or a portion thereof) may be configured as an assembly of hydraulic components (e.g., valves, flow lines, pistons and cylinders, and so on), such that control of various devices (e.g., pumps or motors) may be effected with, and based upon, hydraulic, mechanical, or other signals and movements.

The controller **22** may be in electronic, hydraulic, mechanical, or other communication with various other systems or devices of the loader **10** (or other machinery). For example, the controller **22** may be in electronic or hydraulic communication with various actuators, sensors, and other devices within (or outside of) the loader **10**, including various devices associated with a hydraulic system. The controller **22** may communicate with other systems or devices (including other controllers) in various known ways, including via a CAN bus (not shown) of the loader **10**, via wireless or hydraulic communication means, or otherwise. An example location for the controller **22** is depicted in FIG. **1**. It will be understood, however, that other locations are possible including other locations on the loader **10**, or various remote locations. In some embodiments, the controller **22** may be configured to receive input commands and to interface with an operator via a human-machine interface **26**, which may be disposed inside a cab **28** of the loader **10** for easy access by the operator. The human-machine interface **26** may be configured in a variety of ways and may include one or more joysticks, various switches or levers, one or more buttons, a touchscreen interface that may be overlaid on a display, a keyboard, a speaker, a microphone associated with a speech recognition system, or various other human-machine interface devices.

The loader **10** also has a hydraulic system that includes one or more pumps and accumulators (designated generally by reference number **30**), which may be driven by the engine **12** of the loader **10**. Flow from the pumps **30** may be routed through various control valves and various conduits (e.g., flexible hoses) to drive various hydraulic cylinders, such as hydraulic cylinders **34**, **36**, **38**, shown in FIG. **1**. Flow from the pumps (and accumulators) **30** may also power various other components of the loader **10**. The flow from the pumps **30** may be controlled in various ways (e.g., through control of various electro-hydraulic control valves **40**) to cause movement of the hydraulic cylinders **34**, **36**, **38**, and thus, a HLBAA **50** relative to the loader **10**. In this way, for example, movement of the HLBAA **50** between various positions relative to the chassis **18** of the loader **10** may be implemented by various control signals to the pumps **30**, control valves **40**, and so on.

In the embodiment depicted, a bucket **52** is pivotally mounted to the HLBAA **50**. The bucket **52** may comprise a conventional steel bucket, or may comprise a hybrid loader bucket assembly. As will be discussed in greater detail herein, the HLBAA **50** includes a first or arm assembly **62** and a second arm assembly **64**, which are interconnected via a hollow torque transfer tube **66** to operate in parallel. The arm assemblies **62**, **64** are each coupled to the chassis **18**, directly or via another frame portion of the loader **10**, at one end, and are coupled at an opposite end to the bucket **52** via a carrier **68**, which is pivoted via first and second (left and right) pivot linkages **70**, **72**. In the illustrated example, the carrier **68** comprises first and second (left and right) couplers **74**, **76**, connected by a cross-rod **78**, that mount to the distal ends of the respective arm assemblies **62**, **64** via coupling pins **80**. Additional pins pivotally couple the pivot linkages **70**, **72** between the arm assemblies **62**, **64** and the respective first and second couplers **74**, **76**. The pivot linkages **70**, **72** enable pivotal movement of the bucket **52** upon actuation of the hydraulic cylinders **36**, **38**.

The hydraulic cylinders may be actuated to raise and lower the HLBAA **50** relative to the loader **10**. In the illustrated example, the HLBAA **50** includes two hydraulic cylinders, namely the hydraulic cylinder **34** coupled between the chassis **18** and the arm assembly **62** and a corresponding cylinder on the opposite side of the loader (not shown) coupled between the chassis **18** and the second arm assembly **64**. It should be noted that the loader **10** may have any number of hydraulic cylinders, such as one, three, etc. Each of the hydraulic cylinders **34** includes an end coupled to the chassis **18** (e.g., via a coupling pin) and an end mounted to the respective one of the arm assembly **62** and the second arm assembly **64** (e.g., via another pin). Upon activation of the hydraulic cylinders **34**, the HLBAA **50** may be moved between various positions to elevate the HLBAA **50**, and thus the bucket **52**, relative to the chassis **18** of the loader **10**.

One or more hydraulic cylinders **36** are mounted to the arm assembly **62** and the first pivot linkage **70**, and one or more hydraulic cylinders **38** are mounted to the second arm assembly **64** and the second pivot linkage **72**. In the illustrated example, the loader **10** includes a single hydraulic cylinder **36**, **38** associated with a respective one of the arm assembly **62** and the second arm assembly **64**, respectively. Each of the hydraulic cylinders **36**, **38** includes an end mounted to the respective one of the arm assembly **62** and the second arm assembly **64** (via another pin) and an end mounted to the respective one of the first pivot linkage **70** and the second pivot linkage **72** (via another pin). Upon activation of the hydraulic cylinders **36**, **38**, the bucket **52** may be moved between various positions, namely to pivot the carrier **68**, and thereby the bucket **52**, relative to the HLBAA **50**.

Thus, in the embodiment depicted, the bucket **52** is pivotable about the carrier **68** of the HLBAA **50** by the hydraulic cylinders **36**, **38**. As noted, in some embodiments, a different number or configuration of hydraulic cylinders or other actuators may be used. Thus, it will be understood that the configuration of the hydraulic system and the HLBAA **50** is presented as an example only. In this regard, in other contexts, a hoist boom (e.g. the HLBAA **50**) may be generally viewed as a boom that is pivotally attached to a vehicle frame, and that is also pivotally attached to an end effector (e.g., the bucket **52**). Similarly, the carrier **68** (e.g., the couplers **74**, **76**) may be generally viewed as a component effecting pivotal attachment of a bucket (e.g. the bucket **52**) to a vehicle frame. In this light, a tilt actuator (e.g., the hydraulic cylinders **36**, **38**) may be generally viewed as an actuator for pivoting a receptacle with respect to a hoist boom, and the hoist actuator (e.g. the hydraulic cylinders **34**) may be generally viewed as an actuator for pivoting a hoist boom with respect to a vehicle frame.

In certain applications, sensors (e.g., pressure, flow or other sensors) may be provided to observe various conditions associated with the loader **10**. For example, the sensors may include one or more pressure sensors that observe a pressure within the hydraulic circuit, such as a pressure associated with at least one of the pumps **30**, the control valves **40** and/or one or more hydraulic cylinders **34**, **36**, **38** to observe a pressure within the hydraulic cylinders and generate sensor signals based thereon. In some cases, various sensors may be disposed on or near the carrier **68** and/or the bucket **52**. For example, sensors (e.g. inertial measurement sensors) may be coupled on or near the bucket **52** to observe or measure parameters including the acceleration of the HLBAA **50** and/or the bucket **52** and generate sensor signals, which may indicate if the HLBAA **50** and/or the bucket **52** is accelerating or decelerating. In some embodiments, various sensors (e.g., angular position sensors) may be configured to detect the angular orientation of the bucket **52** relative to the HLBAA **50**, or to detect the angular orientation of the HLBAA **50** relative to the chassis **18**, and various other indicators of the current orientation or position of the bucket **52**. For example, rotary angular position sensors may be used or linear position or displacement sensors may be used to determine the length of the hydraulic cylinders **34**, **36**, **38** relative to the HLBAA **50**.

The bucket **52** generally defines a receptacle for carrying various materials, such as dirt, rocks, wet dirt, sand, hay, etc. In one example, the bucket **52** may receive about two cubic yards of material to over about five cubic yards of material. The bucket **52** is movable upon actuation of the hydraulic cylinders **36**, **38** between a level position, a roll-back position and a dump position, along with various positions in between. In the level position, the bucket **52** can receive various materials. In the roll-back position, the bucket **52** is pivoted upward relative to the earth's surface or ground by the actuation of the hydraulic cylinders **36**, **38** such that the bucket **52** may be loaded with and retain the various materials. In the dump position, the bucket **52** is pivoted downward relative to the earth's surface or ground by the actuation of the hydraulic cylinders **36**, **38** such that the various materials may fall from the bucket **52** to substantially empty the bucket **52**.

Referring to FIG. **1**A, in some embodiments, the HLBAA **50** may be used with a compact utility tractor **1000** having a front loader **1002** removably coupled to the compact utility tractor **1000**. It will be understood that the implementation of the HLBAA **50** with the compact utility tractor **1000** is presented as an example only. Generally, the compact utility tractor **1000** includes a source of propulsion, such as an engine **1012** that supplies power to a transmission **1014**. In one example, the engine **1012** is an internal combustion engine, such as a diesel engine, that is controlled by an engine control module. The transmission **1014** transfers power from the engine **1012** to a suitable driveline coupled to one or more driven wheels **1016** of the compact utility tractor **1000** to enable the compact utility tractor **1000** to move. The engine **1012**, the transmission **1014** and the rest of the driveline are supported by a vehicle chassis **1018**, which is supported off the ground by the wheels **1016**. As is known to one skilled in the art, the transmission **1014** can include a suitable gear transmission, which can be operated in a variety of ranges. The transmission **1014** may be controlled by a transmission control module, which is, along with the engine control module, in communication with a master controller **1022** (or group of controllers).

The controller **1022** may control various aspects of the operation of the compact utility tractor **1000** and may be configured as a computing device with associated processor devices and memory architectures, as a hard-wired computing circuit (or circuits), as a programmable circuit, as a hydraulic, electrical or electro-hydraulic controller, or otherwise. As such, the controller **1022** may be configured to execute various computational and control functionality with respect to the compact utility tractor **1000** (or other machinery). In some embodiments, the controller **1022** may be configured to receive input signals in various formats (e.g., as hydraulic signals, voltage signals, current signals, and so on), and to output command signals in various formats (e.g., as hydraulic signals, voltage signals, current signals, mechanical movements, and so on). In some embodiments, the controller **1022** (or a portion thereof) may be configured as an assembly of hydraulic components (e.g., valves, flow lines, pistons and cylinders, and so on), such that control of various devices (e.g., pumps or motors) may be effected with, and based upon, hydraulic, mechanical, or other signals and movements.

The controller **1022** may be in electronic, hydraulic, mechanical, or other communication with various other systems or devices of the compact utility tractor **1000** (or other machinery), including the front loader **1002**. For example, the controller **1022** may be in electronic or hydraulic communication with various actuators, sensors, and other devices within (or outside of) the compact utility tractor **1000**, including various devices associated with a hydraulic system of the front loader **1002**. The controller **1022** may communicate with other systems or devices (including other controllers) in various known ways, including via a CAN bus (not shown) of the compact utility tractor **1000**, via wireless or hydraulic communication means, or otherwise. An example location for the controller **1022** is depicted in FIG. **1**A. It will be understood, however, that other locations are possible including other locations on the compact utility tractor **1000**, or various remote locations. In some embodiments, the controller **1022** may be configured to receive input commands and to interface with an operator via a human-machine interface **1026**, which may be disposed for easy access by the operator. The human-machine interface **1026** is in communication with the controller **1022** over a suitable communication architecture, such as a CAN bus. The human-machine interface **1026** may be configured in a variety of ways and may include one or more joysticks, various switches or levers, a steering wheel, one or more buttons, a touchscreen interface that may be overlaid on a display, a keyboard, a speaker, a microphone associated with a speech recognition system, or various other human-machine interface devices.

The compact utility tractor **1000** also has a hydraulic system that includes one or more pumps and accumulators (designated generally by reference number **1028**), which may be driven by the engine **1012** of the compact utility tractor **1000**. Flow from the pumps **1028** may be routed through various control valves and various conduits (e.g., flexible hoses) to drive various hydraulic cylinders, such as hydraulic cylinders **34**, **36**, **38** associated with the front loader **1002**, shown in FIG. **1**A. Flow from the pumps (and accumulators) **1028** may also power various other components of the compact utility tractor **1000**. The flow from the pumps **1028** may be controlled in various ways (e.g., through control of various electro-hydraulic control valves **1040**) to cause movement of the hydraulic cylinders **34**, **36**, **38**, and thus, the front loader **1002** relative to the compact utility tractor **1000** when the front loader **1002** is mounted on the compact utility tractor **1000** through a suitable mounting arrangement. In this way, for example, movement of the front loader **1002** between various positions relative to the chassis **1018** of the compact utility tractor **1000** may be implemented by various control signals to the pumps **1028**, control valves **1040**, and so on.

In the embodiment depicted, the front loader **1002** includes the bucket **52** pivotally mounted to the HLBAA **50**. The arm assemblies **62**, **64** are each configured to be coupled to the chassis **18** via a suitable mounting arrangement, at one end, and are coupled at an opposite end to the bucket **52** via the carrier **68**. The mounting arrangement may include a mast **1030** on each side of the front loader **1002** that cooperates with a mounting frame on each side of the compact utility tractor **1000** to removably couple the front loader **1002** to the compact utility tractor **1000**.

As discussed with regard to FIGS. **1** and **2**, the hydraulic cylinders **34** may be actuated to raise and lower the HLBAA **50** relative to the compact utility tractor **1000**. In the illustrated example, the HLBAA **50** includes two hydraulic cylinders, namely the hydraulic cylinder **34** coupled between the mast **1030** of the front loader **1002** and the arm assembly **62** and a corresponding cylinder on the opposite side of the loader (not shown) coupled between the mast **1030** and the second arm assembly **64**. It should be noted that the compact utility tractor **1000** may have any number of hydraulic cylinders, such as one, three, etc. Each of the hydraulic cylinders **34** includes an end coupled to the mast **1030** (e.g., via a coupling pin) and an end mounted to the respective one of the arm assemblies **62**, **64** (e.g., via another pin). Upon activation of the hydraulic cylinders **34**, the HLBAA **50** may be moved between various positions to elevate the HLBAA **50**, and thus the bucket **52**, relative to the chassis **1018** of the compact utility tractor **1000**.

The one or more hydraulic cylinders **36** are mounted to the arm assembly **62** and the first pivot linkage **70**, and the one or more hydraulic cylinders **38** are mounted to the second arm assembly **64** and the second pivot linkage **72**. In the illustrated example, the front loader **1002** includes a single hydraulic cylinder **36**, **38** associated with a respective one of the arm assemblies **62**, **64**, respectively. Each of the hydraulic cylinders **36**, **38** includes an end mounted to a respective one of the arm assemblies **62**, **64** (via a pin) and an end mounted to the respective one of the first pivot linkage **70** and the second pivot linkage **72** (via another pin). Upon activation of the hydraulic cylinders **36**, **38**, the bucket **52** may be moved between various positions, namely to pivot the carrier **68**, and thereby the bucket **52**, relative to the HLBAA **50**. Thus, in the embodiment depicted, the bucket **52** is pivotable about the carrier **68** of the HLBAA **50** by the hydraulic cylinders **36**, **38**. As noted, in some embodiments, a different number or configuration of hydraulic cylinders or other actuators may be used. Accordingly, it will be understood that the configuration of the hydraulic system and the HLBAA **50** is presented as an example only.

Referring also to FIG. **3**, the example HLBAA **50** will now be detailed. The HLBAA **50** includes the arm assembly **62**, the second arm assembly **64** and the hollow torque transfer tube **66** that interconnects the arm assembly **62** and the second arm assembly **64**. Each of the arm assembly **62** and the second arm assembly **64** include a first beam **100**, a second beam **102**, a vehicle mounting subassembly **104**, a respective bucket mount bracket or bucket mount bracket subassembly **106**, **108** and a knee mounting subassembly **110**. Generally, the arm assembly **62** is a mirror image of the second arm assembly **64**.

The first beam **100** and the second beam **102** are each formed from the lightweight material. In one example, with reference to FIG. **4**, the first beam **100** and the second beam **102** are each composed of an inner tube **112**, a pair of reinforcing layers **114** and a pair of reinforcing plates **116**. As the first beam **100** and the second beam **102** have the same composition, the composition of the second beam **102** is illustrated in FIG. **4** with the understanding that the composition of the first beam **100** is the same. The inner tube **112** has a generally rectangular cross-section. In one example, inner tube **112** is formed from a lightweight material, including, but not limited to a polymer-based material. In this example, the inner tube **112** is composed of a polymer-based resin that includes reinforcing fibers and/or reinforcing particles. The reinforcing fibers, include, but are not limited to, glass, basalt, carbon, aramids, olefins, and/or cellulose. The polymer-based resin may be a thermoset or a thermoplastic. In the example of a thermoset polymer-based resin, the polymer-based resin includes, but is not limited to, polyurethane, epoxy, and acrylic. In the example of a thermoplastic polymer-based resin, the polymer-based resin includes, but is not limited to, polyamides, polyolefins, polycarbonates, or polyesters. The inner tube **112** is formed using wet-ply lay-up, pultrusion, hand lay-up, filament winding, extrusion, injection molding, rotomolding, blow molding, etc.

The pair of reinforcing layers **114** are each coupled to the inner tube **112**. In one example, the inner tube **112** includes a first surface **112***a* opposite a second surface **112***b*, and a respective one of the reinforcing layers **114** is coupled to each of the first surface **112***a* and the second surface **112***b*. In this example, the first surface **112***a* and the second surface **112***b* are a top and a bottom surface, respectively of the inner tube **112**. The pair of reinforcing layers **114** provides additional stiffness to the inner tube **112**. The pair of reinforcing layers **114** are each composed of a polymer-based material, including, but not limited to, a carbon fiber reinforced polymer-based material. In one example, the carbon fibers are aligned longitudinally with the inner tube **112** in a tow form. The carbon fibers may also be a continuous strand mat or 0 degree roving, or web. The carbon fiber reinforced polymer-based material may comprise any suitable carbon fiber reinforced polymer-based material known in the art. The carbon fibers may be woven with another material, such as glass fiber, to impart impact resistance. The pair of reinforcing layers **114** are each formed using wet-ply lay-up, pultrusion, hand lay-up, filament winding, etc. The pair of reinforcing layers **114** are coupled to the inner tube **112** by an adhesive, including, but not limited to polyurethane, epoxy, acrylic, etc. As used herein, "adhesive" or "the adhesive" includes, but is not limited to polyurethane, epoxy, acrylic, etc.

The pair of reinforcing plates **116** is each coupled about the inner tube **112** and the pair of reinforcing layers **114** to define an exterior surface of the respective one of the first beam **100** and the second beam **102**. The reinforcing plates **116** are each substantially L-shaped and include a body **118** having an inward projecting flange **120**. One of the pair of reinforcing plates **116** is rotated about 180 degrees relative to the other reinforcing plate **116** such that the body **118** and the respective inward projecting flange **120** cooperate to enclose the inner tube **112** and the pair of reinforcing layers **114**. Each of the reinforcing plates **116** is composed of a metal or metal alloy, such as a steel, and may be formed by stamping, machining, forging, casting, etc. Each of the reinforcing plates **116** are coupled to the inner tube **112** and the pair of reinforcing layers **114** by the adhesive.

With reference to FIG. **5**, the first beam **100** includes a first end **100***a* and an opposite second end **100***b*. The first end **100***a* defines a respective first end of the arm assembly **62** and the second arm assembly **64**. The first beam **100** defines a first through bore **122** at the first end **100***a*, and defines a second through bore **124** at the second end **100***b*. The first through bore **122** receives a portion of the vehicle mounting subassembly **104** to couple the vehicle mounting subassembly **104** to the first beam **100**. The second through bore **124** is coupled to the knee mounting subassembly **110**. It should be understood that each of the first through bore **122** and the second through bore **124** are defined in the first beam **100** so as to extend through each of the pair of reinforcing plates **116** and the inner tube **112**. In one example, the second end **100***b* of the first beam **100** is beveled from a first surface **100***d* to a second, opposite surface **100***c*. By beveling the second end **100***b*, the second end **100***b* of the first beam **100** may be positioned against a cooperating bevel defined on a third end **102***a* of the second beam **102** so that the second beam **102** extends at an angle relative to the first beam **100**.

The second beam **102** includes the third end **102***a* and an opposite fourth end **102***b*. The fourth end **102***b* defines a respective second end of the arm assembly **62** and the second arm assembly **64**. In one example, the third end **102***a* of the second beam **102** is beveled from a first surface **102***d* to a second, opposite surface **102***c*. By beveling the third end **102***a*, the second beam **102** extends at an angle relative to the first beam **100** to assist in coupling the bucket **52** (FIG. **1**) to the HLBAA **50**. The second beam **102** defines a third through bore **126** at the third end **102***a*, and defines a fourth bore **128** and a fifth bore **129** at the fourth end **102***b*. The third through bore **126** is coupled to the knee mounting subassembly **110**. It should be understood that the third through bore **126** is defined in the second beam **102** so as to extend through each of the pair of reinforcing plates **116** and the inner tube **112**. The fourth bore **128** and the fifth bore **129** each receives a portion of the bucket mount bracket subassembly **106**, **108** and the torque transfer tube **66** to couple the bucket mount bracket subassembly **106**, **108** and the torque transfer tube **66** to the second beam **102**. In this example, with reference to FIG. **11**, the fourth bore **128** has a diameter that is less than a diameter of the fifth bore **129**. The fourth bore **128** is defined in the second beam **102** so as to extend through one of the pair of reinforcing plates **116** and the inner tube **112** and so as to be coaxial with the fifth bore **129**. The fifth bore **129** is defined in the second beam **102** so as to extend through the other of the pair of reinforcing plates **116**, and is sized to receive the torque transfer tube **66** therethrough.

The vehicle mounting subassembly **104** is coupled to the first end **100***a* of each first beam **100** of the arm assembly **62** and the second arm assembly **64**. Stated another way, the vehicle mounting subassembly **104** is coupled to the first end of each of the arm assembly **62** and the second arm assembly **64** and is configured to couple the arm assembly **62** and the second arm assembly **64** to the loader **10**. With reference to FIG. **5**, the vehicle mounting subassembly **104** is shown in greater detail. As the vehicle mounting subassembly **104** is the same for both the arm assembly **62** and the second arm assembly **64**, the vehicle mounting subassembly **104** will be shown in detail herein with regard to the first beam **100** of the arm assembly **62** for ease of description, with the understanding that the vehicle mounting subassembly **104** coupled to the second arm assembly **64** is the same.

A portion of the vehicle mounting subassembly **104** passes through the first end **100***a* of the first beam **100** for coupling the respective one of the arm assembly **62** and the second arm assembly **64** to the loader **10**. With reference to FIG. **7**, in one example, the vehicle mounting subassembly **104** includes a pair of lock plates **130**, a sleeve **132** and a block **134**. Each of the pair of lock plates **130** is composed of a metal or metal alloy, including, but not limited to, steel, and is cast, forged, stamped, etc. Each of the pair of lock plates **130** is annular; however, each of the pair of lock plates **130** may have any desired shape. Each of the pair of lock plates **130** defines a central bore **136**. In one example, the central bore **136** includes a plurality of threads **136***a*. The plurality of threads **136***a* cooperates with the sleeve **132** to couple the vehicle mounting subassembly **104** to the first beam **100**. Each of the pair of lock plates **130** may also define a plurality of coupling bores **138**. In one example, each bore **138** of the plurality of coupling bores **138** are spaced apart about a perimeter or circumference of the respective one of the pair of lock plates **130** to receive a tool or instrument to facilitate rotating the respective one of the pair of lock plates **130** into threaded engagement with the sleeve **132**. The pair of lock plates **130** are generally coupled to the first beam **100** so as to be on opposed surfaces **100***e*, **100***f* of the first beam **100**.

The sleeve **132** is received through the first through bore **122** and the block **134**. In this example, the sleeve **132** is a hollow cylinder, and includes a first end **132***a* opposite a second end **132***b* and a midsection **132***c* that extends between the first end **132***a* and the second end **132***b*. The sleeve **132** is composed of a metal or metal alloy, including, but not limited to, steel, and is cast, forged, stamped, etc. The first end **132***a* and the second end **132***b* each include a plurality of threads **140***a*, **140***b*. The plurality of threads **140***a*, **140***b* matingly engage with the plurality of threads **136***a* of a respective one of the pair of lock plates **130** to couple the vehicle mounting subassembly **104** to the first beam **100**. The sleeve **132** defines a sleeve bore **141** that extends from the first end **132***a* to the second end **132***b*. The sleeve bore **141** enables a pin **252** (FIG. **2**) to pass through the vehicle mounting subassembly **104** to couple the respective one of the arm assembly **62** and the second arm assembly **64** to the loader **10**.

The block **134** is sized to be received wholly within the inner tube **112** at the first end **100***a* of the first beam **100**. In one example, the block **134** is substantially square; however, the block **134** may be rectangular. The block **134** is composed of a polymer-based material, including, but not limited to, a glass-reinforced polymer-based material. For example, the block **134** is composed of G10 glass-fiber mat reinforced epoxy material. The block **134** may be formed using wet-ply lay-up, pultrusion, hand lay-up autoclave, compression molding, injection molding, extrusion, etc. The block **134** defines a central cross-bore **142**. With reference to FIG. **8**, the cross-bore **142** receives a portion of the sleeve **132** therethrough. The block **134** supports the sleeve **132** within the first beam **100**. The block **134** may be coupled to the inner tube **112** via the adhesive, which may surround the block **134** to fixedly retain the block **134** within the inner tube **112**.

With reference back to FIG. **5**, the bucket mount bracket subassembly **106**, **108** couples the bucket **52** (FIG. **1**) to the HLBAA **50**. With reference to FIGS. **9** and **10**, the bucket mount bracket subassembly **106** is shown in greater detail. As the bucket mount bracket subassembly **106** is a mirror image of the bucket mount bracket subassembly **108**, for ease of description, the bucket mount bracket subassembly **106** will be discussed herein with the understanding that the bucket mount bracket subassembly **108** is substantially the same. The bucket mount bracket subassembly **106** includes a first outer plate **150**, a second inner plate **152**, a flange assembly **154**, a retaining flange **156** (FIG. **10**) and a second block **158** (FIG. **10**).

The first outer plate **150** is planar, and extends along a third surface **102***e* of the second beam **102**. The third surface **102***e* is opposite a fourth surface **102***f*. In one example, the first outer plate **150** is composed of a metal or metal alloy, such as steel, and may be formed by stamping, casting, forging, etc. With reference to FIG. **10**, the first outer plate **150** has a first plate end **160** and an opposite second plate end **162**. The first plate end **160** defines a first plate bore **164**, which cooperates with the torque transfer tube **66** to couple the torque transfer tube **66** to the arm assembly **62**. The second plate end **162** defines a second plate bore **166**, which receives a portion of the flange assembly **154**. The first outer plate **150** has a first plate surface **150***a* opposite a second plate surface **150***b*. The first plate bore **164** and the second plate bore **166** are defined through the first outer plate **150** so as to extend from the first plate surface **150***a* to the second plate surface **150***b*. The first plate surface **150***a* defines an exterior surface of the first outer plate **150**. A portion of the second plate surface **150***b* is coupled to the respective one of the pair of reinforcing plates **116**, via welding, for example, and a remainder of the second plate surface **150***b* is coupled to the flange assembly **154**.

The second inner plate **152** is planar, and extends along the fourth surface **102***f* of the second beam **102** (FIG. **9**). In one example, the second inner plate **152** is composed of a metal or metal alloy, such as steel, and may be formed by stamping, casting, forging, etc. With reference to FIG. **10**, the second inner plate **152** has a third plate end **170** and an opposite fourth plate end **172**. The third plate end **170** defines a third plate bore **174**, which cooperates with the torque transfer tube **66** to couple the torque transfer tube **66** to the arm assembly **62**. The fourth plate end **172** defines a fourth plate bore **176**, which receives a portion of the flange assembly **154**. The second inner plate **152** has a third plate surface **152***a* opposite a fourth plate surface **152***b*. The third plate bore **174** and the fourth plate bore **176** are defined through the second inner plate **152** so as to extend from the third plate surface **152***a* to the fourth plate surface **152***b*. A portion of the third plate surface **152***a* is coupled to the respective one of the pair of reinforcing plates **116**, via welding, for example, and a remainder of the third plate surface **152***a* is coupled to the flange assembly **154**. The fourth plate surface **152***b* defines an exterior surface of the second inner plate **152**.

The flange assembly **154** cooperates with the first outer plate **150** and the second inner plate **152** for coupling the bucket **52** (FIG. **1**) to the arm assembly **62**. In one example, the flange assembly **154** includes a base **180**, a pair of retaining flanges **182** and a bushing **184**. The base **180** and the pair of retaining flanges **182** are generally integrally formed, and may be stamped, cast, machined, etc. The base **180** and the pair of retaining flanges **182** may be composed of metal or metal alloy, including, but not limited to, steel. The base **180** is substantially flat or planar, and includes a first base surface **180***a* opposite a second base surface **180***b*. The first base surface **180***a* is coupled to the retaining flange **156**, via welding, for example. The pair of retaining flanges **182** extend upwardly from opposed sides of the second base surface **180***b*. Each of the pair of retaining flanges **182** defines a bore **186**. Each of the bores **186** are coaxially aligned and configured to receive the bushing **184**.

The bushing **184** comprises a hollow cylinder, which has a first bushing end **184***a* opposite a second bushing end **184***b*. A bushing midsection **184***c* extends between the first bushing end **184***a* and the second bushing end **184***b*. The bushing **184** is composed of metal or metal alloy, including, but not limited to, steel, and is cast, forged, stamped, extruded, etc. The first bushing end **184***a* is received through a respective one of the bores **186** and is coupled to the respective one of the pair of retaining flanges **182**, via welding, for example. The second bushing end **184***b* is received through a respective one of the bores **186** and is coupled to the respective one of the pair of retaining flanges **182**, via welding, for example. The bushing midsection **184***c* is positioned between the pair of retaining flanges **182**, and is configured to receive a portion of a hook **52***a* (FIG. **2**) of the bucket **52** to couple the bucket **52** to the arm assembly **62**.

The retaining flange **156** is substantially U-shaped, and is composed of metal or metal alloy, including, but not limited to, steel, and is cast, forged, stamped, extruded, etc. In this example, the retaining flange **156** includes a first leg **190**, an opposite second leg **192** and a retaining base **194**. The first leg **190** and the second leg **192** extend outwardly from the retaining base **194**. The retaining base **194** includes a first surface **194***a* opposite a second surface **194***b*. The second surface **194***b* is coupled to the first base surface **180***a* of the base **180** of the flange assembly **154**. In one example, the second surface **194***b* is coupled to the first base surface **180***a* via welding. The first leg **190**, the second leg **192** and the first surface **194***a* of the retaining base **194** are each coupled to the second block **158**.

The second block **158** is received wholly within the inner tube **112** at the fourth end **102***b* of the second beam **102**. In one example, the second block **158** is substantially square; however, the second block **158** may be rectangular. The second block **158** is composed of a polymer-based material, including, but not limited to, a glass-reinforced polymer-based material. For example, the second block **158** is composed of G10 glass-fiber mat reinforced epoxy material. The second block **158** may be formed using wet-ply lay-up, pultrusion, hand lay-up autoclave, compression molding, injection molding, extrusion, etc. The second block **158** defines a central second cross-bore **196**, and a pair of opposed slots **198**. As will be discussed, the second cross-bore **196** receives a portion of the torque transfer tube **66** therethrough. The second block **158** supports the torque transfer tube **66** within the second beam **102**. With reference to FIG. **11**, the second block **158** is shown received within the inner tube **112** such that the fourth bore **128** and the fifth bore **129** of the second beam **102** are coaxially aligned with the second cross-bore **196**. The pair of opposed slots **198** receive a respective one of the first leg **190** and the second leg **192**. Each of the pair of opposed slots **198** include a layer of the adhesive, such that the respective one of the first leg **190** and the second leg **192** are coupled to the second block **158** via the adhesive layer defined in the respective one of the slots **198**. With reference back to FIG. **10**, the first surface **194***a* of the retaining base **194** is also coupled to a side **158***a* of the second block **158**, via the adhesive, for example. In addition, the second block **158** may be coupled to the inner tube **112** via the adhesive, which may surround the second block **158** to fixedly retain the second block **158** within the inner tube **112**.

As shown in FIG. **12**, the bucket mount bracket subassembly **106** is coupled to the second beam **102** such that the second block **158** is received wholly within the inner tube **112** of the second beam **102**, and the flange assembly **154** is disposed external to the second beam **102**. The first leg **190** and the second leg **192** are coupled to the slots **198**, and the retaining base **194** is coupled to the base **180** of the flange assembly **154**.

With reference to FIG. **13**, the knee mounting subassembly **110** interconnects the first beam **100** with the second beam **102**. The knee mounting subassembly **110** includes a pair of knee plates **200**, an angled block **202** (FIG. **14**) and a pair of coupling pins **204**. The pair of knee plates **200** comprises connecting plates for interconnecting the first beam **100** with the second beam **102**. Each of the knee plates **200** is composed of metal or metal alloy, including, but not limited to, steel, and is cast, forged, stamped, extruded, etc. The knee plates **200** are each coupled to a respective two of the reinforcing plates **116**, via welding, for example. With reference to FIG. **14**, each of the pair of knee plates **200** includes a first plate end **206** opposite a second plate end **208**, and a first plate side **210** opposite a second plate side **212**. The first plate end **206** defines a first plate bore **214** for coupling the respective knee plate **200** to the first beam **100**. A second plate bore **216** is defined through each of the knee plates **200** between the first plate bore **214** and the second plate end **208**. Each of the knee plates **200** also defines a first pin bore **218** along the first plate side **210** and a second pin bore **220** along the second plate side **210**. The first pin bore **218** receives one of the coupling pins **204**, and the second pin bore **220** receives the other of the coupling pins **204**.

With reference to FIG. **15**, the angled block **202** is received wholly within a portion of the first beam **100** and the second beam **102** when the arm assembly **62** is assembled. The angled block **202** is composed of a polymer-based material, including, but not limited to, a glass-reinforced polymer-based material. For example, the angled block **202** is composed of G10 glass-fiber mat reinforced epoxy material. The angled block **202** may be formed using wet-ply lay-up, pultrusion, hand lay-up autoclave, compression molding, injection molding, extrusion, etc. With reference back to FIG. **14**, the angled block **202** has a first block end **222** and a second block end **224**. The second block end **224** is angled relative to the first block end **222**. Stated another way, the first block end **222** extends along an axis A, and the second block end **224** extends along a second axis A**2**, and the second axis A**2** is oblique to the axis A. A first block bore **226** is defined through the angled block **202** at the first block end **222**, and a second block bore **228** is defined through the angled block **202** at the second block end **224**. When the angled block **202** is positioned within the first beam **100** and the second beam **102**, the first block bore **226** is coaxially aligned with the second through bore **124** of the first beam **100** and the second block bore **228** is coaxially aligned with the third through bore **126** of the second beam **102**. When the knee plates **200** are coupled to the respective reinforcing plates **116**, the first plate bore **214** is coaxially aligned with the second through bore **124** of the first beam **100** and the first block bore **226** to enable a mechanical fastener **227**, such as a bolt, to be received through the first plate bore **214** of each of the knee plates **200**, the first block bore **226** and the second through bore **124**, and secured with a flange nut **229**, for example, to couple the first beam **100** to the pair of knee plates **200**. The second plate bore **216** is coaxially aligned with the third through bore **126** of the second beam **102** and the second block bore **228** to enable another mechanical fastener **227**, such as a bolt, to be received through the second plate bore **216** of each of the knee plates **200**, the second block bore **228** and the third through bore **126** and secured with another flange nut **229**, for example, to couple the second beam **102** to the pair of knee plates **200**. In addition, the angled block **202** may be coupled to the inner tube **112** of each of the first beam **100** and the second beam **102** via the adhesive, which may surround the angled block **202** to fixedly retain the angled block **202** within the inner tube **112** of each of the first beam **100** and the second beam **102**.

The pair of coupling pins **204** couple the hydraulic cylinders **34**, **36**, **38** to the respective one of the arm assembly **62** and the second arm assembly **64**. Each of the coupling pins **204** includes a pair of collars **230**. The pair of collars **230** secures and retains the coupling pins **204** to the pair of knee plates **200**. Generally, one of the coupling pins **204** is received through each of the first pin bores **218** and the other one of the coupling pins **204** is received through each of the second pin bores **220**. A first one of the collars **230** is coupled to one end of one of the coupling pins **204**, and a second one of the pair of collars **230** is coupled to the other opposed end of the respective one of the coupling pins **204**. One of the pair of collars **230** is coupled to one end of the other one of the coupling pins **204**, and the second one of the pair of collars **230** is coupled to the opposed end of the other coupling pins **204**. Thus, each of the collars **230** includes a central collar bore **230***a* that receives the respective end of the coupling pin **204** therein (FIG. **13**). In one example, each end of the coupling pins **204** includes a through bore **204***a* that cooperates with corresponding cross-bores **230***b* defined in each of the collars **230**. A pin is received within the through bores **204***a* and the cross-bores **230***b* to couple the coupling pins **204** to the knee plates **200**. Each of the coupling pins **204** may also include a bore **204***b*, which receives a pin, to couple the respective hydraulic cylinders **34**, **36**, **38** to the respective one of the arm assembly **62** and the second arm assembly **64**.

With reference back to FIG. **3**, the torque transfer tube **66** interconnects the arm assembly **62** and the second arm assembly **64**. The torque transfer tube **66** is coupled to each of the arm assembly **62** and the second arm assembly **64** at the fourth end **102***b* of the respective second beam **102**. With reference to FIG. **16**, the torque transfer tube **66** has a first tube end **240** and an opposite second tube end **242**. The first tube end **240** is coupled to the arm assembly **62**, and the second tube end **242** is coupled to the second arm assembly **64**. The torque transfer tube **66** is a hollow cylindrical tube, and is composed of a polymer-based material. In one example, the torque transfer tube **66** is composed of a polymer-based resin that includes reinforcing fibers and/or reinforcing particles. The reinforcing fibers, include, but are not limited to, glass, basalt, carbon, aramids, olefins, and/or cellulose. The polymer-based resin may be a thermoset or a thermoplastic. In the example of a thermoset polymer-based resin, the polymer-based resin includes, but is not limited to, polyurethane, epoxy, and acrylic. In the example of a thermoplastic polymer-based resin, the polymer-based resin includes, but is not limited to, polyamides, polyolefins, polycarbonates, or polyesters. The torque transfer tube **66** is formed using wet-ply lay-up, pultrusion, hand lay-up, filament winding, extrusion, injection molding, rotomolding, blow molding, etc.

With reference to FIG. **17**, the first tube end **240** is shown in greater detail. As the first tube end **240** is a mirror image of the second tube end **242**, the first tube end **240** will be described in detail herein with the understanding that the second tube end **242** is substantially the same. The first tube end **240** includes a third block **244**. The third block **244** is received wholly within the torque transfer tube **66** at the first tube end **240**. In one example, with reference to FIG. **18**, the third block **244** is substantially cylindrical; however, the third block **244** may have any desired shape. The third block **244** is composed of a polymer-based material, including, but not limited to, a glass-reinforced polymer-based material. For example, the third block **244** is composed of G10 glass-fiber mat reinforced epoxy material. The third block **244** may be formed using wet-ply lay-up, pultrusion, hand lay-up autoclave, compression molding, injection molding, extrusion, etc. The third block **244** includes a mechanical fastener **246**, such as a bolt, which is integrally formed with or monolithic with the third block **244**. The mechanical fastener **246** is generally formed with the third block **244** such that the mechanical fastener **246** extends along a central axis A**3** of the third block **244** or is centered relative to the third block **244**. The mechanical fastener **246** is formed with the third block **244** such that a shank **246***a* of the mechanical fastener **246** extends a distance beyond the third block **244** for receiving a flange nut **248**, for example, to couple the first tube end **240** to the arm assembly **62**.

It should be noted that while the third block **244** is described herein as being composed of G10 material, the third block **244** may alternatively be composed of a bulk molding compound, including, but not limited to, glass-fiber reinforced thermoset or thermoplastic polymer-based material. In the example of the third block **244** composed of bulk molding compound, the mechanical fastener **246** may be molded into the bulk molding compound, via compression or injection molding, for example, to form the third block **244**.

Generally, with reference to FIG. **16**, when the torque transfer tube **66** is coupled to the arm assembly **62**, the first tube end **240** is received through the second cross-bore **196** of the second block **158** and the shank **246***a* of the mechanical fastener **246** extends through the fourth bore **128** of the second beam **102** and the first plate bore **164** of the first outer plate **150**. The flange nut **248** is coupled to the shank **246***a* and tightened to the first outer plate **150** for coupling the torque transfer tube **66** to the arm assembly **62**. In addition, the adhesive may be applied to a surface **244***a* of the third block **244** (FIG. **18**) to aid in coupling the third block **244** to the inner tube **112** of the second beam **102**. Further, the adhesive may be applied about a second surface **244***b* (FIG.

18) or the perimeter of the third block **244** to aid in coupling the third block **244** to the first tube end **240** of the torque transfer tube **66**. In one example, the adhesive is also applied about the second cross-bore **196** to further couple the first tube end **240** to the second block **158**.

With reference back to FIG. **5**, the first beams **100**, the second beams **102**, the vehicle mounting assemblies **104**, the bucket mount bracket subassemblies **106**, **108**, the knee mounting subassemblies **110**, the torque transfer tube **66**, the adhesive, the mechanical fasteners **227** and the flange nuts **229** comprise a kit **250** for the HLBAA **50**. In one example, in order to assemble the arm assembly **62** and the second arm assembly **64**, the reinforcing layers **114** are coupled to the inner tubes **112**, via the adhesive, for example. With the angled blocks **202** formed, with reference to FIG. **15**, the angled blocks **202** are inserted into a second end **112***c* of a respective one of the inner tubes **112** associated with the first beam **100** and a first end **112***d* of a respective one of the inner tubes **112** associated with the second beam **102** to couple two of the inner tubes **112** together. This is repeated to form two subassemblies, one for each of the arm assembly **62** and the second arm assembly **64**. The adhesive may be applied to the angled blocks **202** and used to couple the angled blocks **202** to the inner tubes **112**.

With reference to FIG. **10**, with the retaining flanges **182** formed with the base **180**, the bushing **184** is inserted through the bores **186** and coupled to the retaining flanges **182**, via welding, for example. With the retaining flange **156** formed, the retaining flange **156** is coupled to the base **180**, via welding, for example. With the second block **158** formed, the retaining flange **156** is coupled to the second block **158**. Generally, with a layer of the adhesive applied to the slots **198** and the surface **158***a* of the second block **158**, the first leg **190** and the second leg **192** are coupled to the slots **198** such that the first surface **194***a* contacts the surface **158***a* of the second block **158**. The second block **158** is inserted into a second end **112***e* of the inner tube **112** associated with one of the second beams **102**. In one example, the adhesive is applied about the second block **158** to further couple the second block **158** to the inner tube **112**. This process is repeated to couple another one of the second blocks **158** to the inner tube **112** associated with the other of the second beams **102**.

With reference to FIG. **7**, with the blocks **134** formed, one of the blocks **134** is inserted into a first end **112***d* of the inner tube **112** associated with one of the first beams **100**, and the other of the blocks **134** is inserted into the first end **112***d* of the inner tube **112** associated with the other of the first beams **100**. The blocks **134** may be coupled to the inner tubes **112** via the adhesive, which may surround the blocks **134** to fixedly retain the blocks **134** within the inner tubes **112**. One of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the inner tube **112** associated with the first beam **100** of the arm assembly **62**, and the other of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the inner tube **112** associated with the first beam **100** of the second arm assembly **64**.

With reference to FIGS. **4** and **5**, with the reinforcing plates **116** formed, the reinforcing plates **116** are coupled about each of the first beam **100** and the second beam **102**, via the adhesive, for example. The knee plates **200** are coupled to the reinforcing plates **116**, via welding, for example. The first outer plate **150** and the second inner plate **152** are coupled to the reinforcing plates **116** associated with the second beams **102**, via welding, for example. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the arm assembly **62**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **100** of the arm assembly **62**. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the second arm assembly **64**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **100** of the second arm assembly **64**.

With reference to FIG. **14**, the mechanical fasteners **227** are inserted through the first plate bores **214** of each pair of knee plates **200** and the first block bore **226** of the angled block **202**. The mechanical fasteners **227** are secured with the flange nut **229**. The mechanical fasteners **227** are inserted through the second plate bores **216** of each pair of knee plates **200** and the second block bore **228** of the angled block **202**. The mechanical fasteners **227** are secured with the flange nut **229** to reinforce the connection of the knee plates **200** to the respective first beam **100** and the second beam **102**. The coupling pins **204** are inserted through the first pin bore **218** and the second pin bore **220**, respectively, and the collars **230** are coupled about the opposed ends of the coupling pins **204**. Pins are inserted through the bores **204***a* of the coupling pins **204** and the cross-bores **232***b* of the collars **230** to couple the coupling pins **204** to the respective pair of knee plates **200**.

With reference to FIGS. **18** and **19**, with the torque transfer tube **66** formed, the adhesive is applied to the surface **244***a* and the second surface **244***b* of the third block **244** and the third block **244** is inserted into the first tube end **240**. This process is repeated to couple another one of the third blocks **244** to the second tube end **242**. With the third block **244** coupled to the first tube end **240**, the first tube end **240** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **102** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the first tube end **140** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the first tube end **240** to the arm assembly **62**. With reference to FIG. **16**, the second tube end **242** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **102** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the second tube end **242** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the second tube end **242** to the arm assembly **62**.

With the HLBAA **50** assembled, with reference to FIG. **2**, the first end **100***a* of the first beams **100** of the HLBAA **50** may be coupled to the loader **10** (FIG. **1**) or the compact utility tractor **1000** (FIG. **1**A) via a pin **252** engaging the sleeves **132** of the respective vehicle mounting assemblies **104**. The fourth end **102***b* of the second beams **102** of the HLBAA **50** may be coupled to the respective couplers **74**, **76** for coupling the bucket **52** (FIG. **1** or FIG. **1**A) to the HLBAA **50** by engaging the coupling pins **80** with each of the bushings **184** of each of the bucket mount bracket subassemblies **106**, **108** and the couplers **74**, **76**. The hydraulic cylinders **34**, **36**, **38** may also be coupled to the coupling pins **204** of the arm assembly **62** and the second arm assembly **64**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to

FIGS. **20-35**, a HLBAA **300** is shown. As the HLBAA **300** includes components that are substantially similar to or the same as the HLBAA **50** discussed with regard to FIGS. **1-19**, the same reference numerals will be used to denote the same or similar features. The HLBAA **300** may couple the bucket **52** to the loader **10**, or may couple the bucket **52** to the compact utility tractor **1000**. It should be noted that the HLBAA **300** may also be used with a variety of other work vehicles. In this example, the HLBAA **300** includes an arm assembly **302**, a second arm assembly **304** and the hollow torque transfer tube **66** that interconnects the arm assembly **302** and the second arm assembly **304**. Each of the arm assembly **302** and the second arm assembly **304** include a first beam **310**, a second beam **312**, a vehicle mounting subassembly **314**, a respective bucket mount bracket or bucket mount bracket subassembly **316**, **318** and a knee mounting subassembly **320**. Generally, the arm assembly **302** is a mirror image of the second arm assembly **304**.

The first beam **310** and the second beam **312** are each formed from the lightweight material. In one example, with reference to FIG. **21**, the first beam **310** and the second beam **312** are each composed of the inner tube **112** and an outer tube **322**. As the first beam **310** and the second beam **312** have the same composition, the composition of the first beam **310** is illustrated in FIG. **20** with the understanding that the composition of the second beam **312** is the same. The outer tube **322** has a generally rectangular cross-section, and is sized to receive the inner tube **112** such that the inner tube **112** is disposed wholly within the outer tube **322** (FIG. **22**). In one example, outer tube **322** is formed from a lightweight material, including, but not limited to a polymer-based material. In this example, the outer tube **322** is composed of a polymer-based resin that includes reinforcing fibers and/or reinforcing particles. The reinforcing fibers, include, but are not limited to, glass, basalt, carbon, aramids, olefins, and/or cellulose. The polymer-based resin may be a thermoset or a thermoplastic. In the example of a thermoset polymer-based resin, the polymer-based resin includes, but is not limited to, polyurethane, epoxy, and acrylic. In the example of a thermoplastic polymer-based resin, the polymer-based resin includes, but is not limited to, polyamides, polyolefins, polycarbonates, or polyesters. The outer tube **322** is formed using wet-ply lay-up, pultrusion, hand lay-up, filament winding, extrusion, injection molding, rotomolding, blow molding, etc. In one example, the adhesive is applied between an inner surface **322***a* of the outer tube **322** and an outer surface **112***g* of the inner tube **112** to couple the outer tube **322** to the inner tube **112**. For example, the adhesive is applied as a coating, for example, on the outer surface **112***g* of the inner tube **112**.

With reference to FIG. **23**, the first beam **310** includes a first end **310***a* and an opposite second end **310***b*. The first end **310***a* defines a respective first end of the arm assembly **302** and the second arm assembly **304**. The first beam **310** defines the first through bore **122** at the first end **310***a*, and defines the second through bore **124** at the second end **310***b*. The first through bore **122** receives a portion of the vehicle mounting subassembly **314** to couple the vehicle mounting subassembly **314** to the first beam **310**. The second through bore **124** is coupled to the knee mounting subassembly **320**. It should be understood that each of the first through bore **122** and the second through bore **124** are defined in the first beam **310** so as to extend through the inner tube **112** and the outer tube **322**. In one example, the second end **310***b* of the first beam **310** is beveled from a first surface **310***d* to a second, opposite surface **310***c*. By beveling the second end **310***b*, the second end **310***b* of the first beam **310** may be positioned against a cooperating bevel defined on a third end **312***a* of the second beam **312** so that the second beam **312** extends at an angle relative to the first beam **310**.

The second beam **312** includes the third end **312***a* and an opposite fourth end **312***b*. The fourth end **312***b* defines a respective second end of the arm assembly **302** and the second arm assembly **304**. In one example, the third end **312***a* of the second beam **312** is beveled from a first surface **312***d* to a second, opposite surface **312***c*. By beveling the third end **312***a*, the second beam **312** extends at an angle relative to the first beam **310** to assist in coupling the bucket **52** (FIG. **1**) to the HLBAA **300**. The second beam **312** defines the third through bore **126** at the third end **312***a*, and defines the fourth bore **128** and the fifth bore **129** at the fourth end **312***b*. The third through bore **126** is coupled to the knee mounting subassembly **320**. It should be understood that the third through bore **126** is defined in the second beam **312** so as to extend through each of the outer tube **322** and the inner tube **112**. The fourth bore **128** and the fifth bore **129** each receives a portion of the bucket mount bracket subassembly **316**, **318** and the torque transfer tube **66** to couple the bucket mount bracket subassembly **316**, **318** and the torque transfer tube **66** to the second beam **312**. In this example, the fourth bore **128** is defined in the second beam **102** so as to extend through one side of the outer tube **322** and the inner tube **112** and so as to be coaxial with the fifth bore **129**. The fifth bore **129** is defined in the second beam **312** so as to extend through the other side of the outer tube **322** and the inner tube **112**, and is sized to receive the torque transfer tube **66** therethrough.

The vehicle mounting subassembly **314** is coupled to the first end **310***a* of each first beam **310** of the arm assembly **302** and the second arm assembly **304**. Stated another way, the vehicle mounting subassembly **314** is coupled to the first end of each of the arm assembly **302** and the second arm assembly **304** and is configured to couple the arm assembly **302** and the second arm assembly **304** to the loader **10**. With reference to FIG. **24**, the vehicle mounting subassembly **314** is shown in greater detail. As the vehicle mounting subassembly **314** is the same for both the arm assembly **302** and the second arm assembly **304**, the vehicle mounting subassembly **314** will be shown in detail herein with regard to the first beam **310** of the arm assembly **302** for ease of description, with the understanding that the vehicle mounting subassembly **314** coupled to the second arm assembly **304** is the same.

A portion of the vehicle mounting subassembly **314** passes through the first end **310***a* of the first beam **310** for coupling the respective one of the arm assembly **302** and the second arm assembly **304** to the loader **10** (FIG. **1**). With reference to FIG. **25**, in one example, the vehicle mounting subassembly **314** includes the pair of lock plates **130**, the sleeve **132**, the block **134** and a pair of reinforcing plates **330**.

The pair of lock plates **130** is generally coupled to the first beam **310** so as contact a respective one of the pair of reinforcing plates **330**. The sleeve **132** is received through the first through bore **122** and the block **134**, and the plurality of threads **140***a*, **140***b* matingly engage with the plurality of threads **136***a* of a respective one of the pair of lock plates **130** to couple the vehicle mounting subassembly **314** to the first beam **310**. The sleeve **132** enables the pin **252** (FIG. **2**) to pass through the vehicle mounting subassembly **314** the couple the respective one of the arm assembly **302** and the second arm assembly **304** to the loader **10** (FIG. **1**). The block **134** is sized to be received wholly within the inner tube **112** at the first end **310***a* of the first beam **310**. The block

134 supports the sleeve **132** within the first beam **310**. The block **134** may be coupled to the inner tube **112** via the adhesive, which may surround the block **134** to fixedly retain the block **134** within the inner tube **112**.

The pair of reinforcing plates **330** is each coupled about the outer tube **322** at the first end **310***a* of the first beam **310** to define an exterior surface of the first beam **310** at the first end **310***a*. The reinforcing plates **330** are each substantially L-shaped and include a body **332** having an inwardly projecting flange **334**. One of the pair of reinforcing plates **330** is rotated about 180 degrees relative to the other reinforcing plate **330** such that the body **332** and the respective inwardly projecting flange **334** cooperate to enclose the outer tube **322**. Each of the reinforcing plates **330** is composed of a metal or metal alloy, such as a steel, and may be formed by stamping, machining, forging, casting, etc. Each of the reinforcing plates **330** are coupled to the outer tube **322** by the adhesive. The body **332** of each of the reinforcing plates **330** defines a central plate bore **336**. With regard to FIG. **26**, each of the central plate bores **336** receives a portion of the sleeve **132** therethrough to enable the ends **132***a*, **132***b* of the sleeve **132** to matingly engage with the respective one of the lock plates **130**.

With reference back to FIG. **23**, the bucket mount bracket subassembly **316**, **318** couples the bucket **52** (FIG. **1**) to the HLBAA **300**. With reference to FIGS. **27** and **28**, the bucket mount bracket subassembly **316** is shown in greater detail. As the bucket mount bracket subassembly **316** is a mirror image of the bucket mount bracket subassembly **318**, for ease of description, the bucket mount bracket subassembly **316** will be discussed herein with the understanding that the bucket mount bracket subassembly **318** is substantially the same. The bucket mount bracket subassembly **316** includes the first outer plate **150**, the second inner plate **152**, the flange assembly **154**, the retaining flange **156** (FIG. **28**), the second block **158** (FIG. **28**), a first reinforcing plate **340** and a second reinforcing plate **342**.

The first outer plate **150** is planar, and extends along a portion of the second reinforcing plate **342** (FIG. **27**). The first plate surface **150***a* defines an exterior surface of the first outer plate **150**. A portion of the second plate surface **150***b* is coupled to the second reinforcing plate **342**, via welding, for example, and a remainder of the second plate surface **150***b* is coupled to the flange assembly **154**. The second inner plate **152** is planar, and extends along a portion of the first reinforcing plate **340** (FIG. **27**). A portion of the third plate surface **152***a* is coupled to the first reinforcing plates **340**, via welding, for example, and a remainder of the third plate surface **152***a* is coupled to the flange assembly **154**. The fourth plate surface **152***b* defines an exterior surface of the second inner plate **152**. The flange assembly **154** cooperates with the first outer plate **150** and the second inner plate **152** for coupling the bucket **52** (FIG. **1**) to the arm assembly **302**. The second block **158** is received wholly within the inner tube **112** at the fourth end **312***b* of the second beam **312**. With reference to FIG. **29**, the second block **158** is shown received within the inner tube **112** such that the fourth bore **128** and the fifth bore **129** of the second beam **312** are coaxially aligned with the second cross-bore **196**. In addition, the second block **158** may be coupled to the inner tube **112** via the adhesive, which may surround the second block **158** to fixedly retain the second block **158** within the inner tube **112**.

As shown in FIG. **12**, the bucket mount bracket subassembly **106** is coupled to the second beam **102** such that the second block **158** is received wholly within the inner tube **112** of the second beam **102**, and the flange assembly **154** is disposed external to the second beam **102**. The first leg **190** and the second leg **192** are coupled to the slots **198**, and the retaining base **194** is coupled to the base **180** of the flange assembly **154**.

The first reinforcing plate **340** and the second reinforcing plate **342** are coupled about the outer tube **322** at the fourth end **312***b* of the second beam **312** to define an exterior surface of the second beam **312** at the fourth end **312***b*. The first reinforcing plate **340** and the second reinforcing plate **342** are each substantially L-shaped. Each of the first reinforcing plate **340** and the second reinforcing plate **342** are composed of a metal or metal alloy, such as a steel, and may be formed by stamping, machining, forging, casting, etc. Each of the first reinforcing plate **340** and the second reinforcing plate **342** are coupled to the outer tube **322** by the adhesive. The first reinforcing plate **340** includes a body **344** having an inwardly projecting flange **346**. The body **344** defines a central bore **348**. With reference to FIG. **30**, the central bore **348** is coaxial with the first plate bore **164** of the first outer plate **150** and the fourth bore **128** of the second beam **312** when assembled. With reference back to FIG. **28**, the second reinforcing plate **342** includes a body **350** having an inwardly projecting flange **352**. The body **350** defines a second central bore **354**. With reference to FIG. **30**, the second central bore **354** is coaxial with the third plate bore **174** of the second inner plate **152** and the fifth bore **129** of the second beam **312** when assembled. As shown in FIG. **27**, the first reinforcing plate **340** and the second reinforcing plate **342** cooperate to enclose the outer tube **322** at the fourth end **312***b*.

With reference to FIG. **31**, the knee mounting subassembly **320** interconnects the first beam **310** with the second beam **312**. The knee mounting subassembly **320** includes the pair of knee plates **200**, the angled block **202** (FIG. **32**), the pair of coupling pins **204**, a first pair of reinforcing plates **360** and a second pair of reinforcing plates **362**. The knee plates **200** are each coupled to each of the first pair of reinforcing plates **360** and the second pair of reinforcing plates **362**, via welding, for example. With reference to FIG. **32**, the angled block **202** is received wholly within a portion of the inner tube **112** of the first beam **310** and a portion of the inner tube **112** of the second beam **312** when the arm assembly **302** is assembled. When the angled block **202** is positioned within the first beam **310** and the second beam **312**, the first block bore **226** is coaxially aligned with the second through bore **124** of the first beam **310** and the second block bore **228** is coaxially aligned with the third through bore **126** of the second beam **312**. The pair of coupling pins **204** couple the hydraulic cylinders **34**, **36**, **38** to the respective one of the arm assembly **302** and the second arm assembly **304**.

The first pair of reinforcing plates **360** is coupled about the outer tube **322** at the second end **310***b* of the first beam **310** to define an exterior surface of the first beam **310** at the second end **310***b*. The first pair of reinforcing plates **360** is substantially L-shaped and includes a body **364** having an inwardly projecting flange **368**. One of the first pair of reinforcing plates **360** is rotated about 180 degrees relative to the other reinforcing plate **360** such that the body **364** and the respective inwardly projecting flange **368** of each of the first pair of reinforcing plates **360** cooperate to enclose the outer tube **322**. Each of the first pair of reinforcing plates **360** is composed of a metal or metal alloy, such as a steel, and may be formed by stamping, machining, forging, casting, etc. Each of the first pair of reinforcing plates **360** are coupled to the outer tube **322** by the adhesive. The body **364** of each of the first pair of reinforcing plates **360** defines a central plate bore **370**.

The second pair of reinforcing plates **362** is coupled about the outer tube **322** at the third end **312***a* of the second beam **312** to define an exterior surface of the second beam **312** at the third end **312***a*. The second pair of reinforcing plates **362** is substantially L-shaped and includes a body **372** having an inwardly projecting flange **374**. One of the second pair of reinforcing plates **362** is rotated about 180 degrees relative to the other reinforcing plate **362** such that the body **372** and the respective inwardly projecting flange **374** of each of the second pair of reinforcing plates **362** cooperate to enclose the outer tube **322**. Each of the second pair of reinforcing plates **362** is composed of a metal or metal alloy, such as a steel, and may be formed by stamping, machining, forging, casting, etc. Each of the second pair of reinforcing plates **362** are coupled to the outer tube **322** by the adhesive. The body **372** of each of the second pair of reinforcing plates **362** defines a central plate bore **376**.

When the knee plates **200** are coupled to the first pair of reinforcing plates **360**, the central plate bore **370** is coaxially aligned with the second through bore **124** of the first beam **310** and the first block bore **226** to enable the mechanical fastener **227** to be received through the first plate bore **214** of each of the knee plates **200**, the first block bore **226**, the second through bore **124** and the central plate bore **370**, and secured with the flange nut **229** to couple the first beam **310** to the pair of knee plates **200**. The central plate bore **376** is coaxially aligned with the third through bore **126** of the second beam **312** and the second block bore **228** to enable another mechanical fastener **227** to be received through the second plate bore **216** of each of the knee plates **200**, the second block bore **228**, the third through bore **126** and the central plate bore **376** and secured with another flange nut **229** to couple the second beam **312** to the pair of knee plates **200**.

With reference back to FIG. **20**, the torque transfer tube **66** interconnects the arm assembly **302** and the second arm assembly **304**. The torque transfer tube **66** is coupled to each of the arm assembly **302** and the second arm assembly **304** at the fourth end **312***b* of the respective second beam **312**. With reference to FIG. **33**, the first tube end **240** is coupled to the arm assembly **302**, and the second tube end **242** is coupled to the second arm assembly **304**. With reference to FIG. **34**, the first tube end **240** is shown coupled to the second beam **312** in greater detail. The third block **244** is received wholly within the torque transfer tube **66** at the first tube end **240**. Generally, when the torque transfer tube **66** is coupled to the arm assembly **302**, the first tube end **240** is received through the second cross-bore **196** of the second block **158** and the shank **246***a* of the mechanical fastener **246** extends through the fourth bore **128** of the second beam **312**, the second central bore **354** of the second reinforcing plate **342** and the first plate bore **164** of the first outer plate **150**. The flange nut **248** is coupled to the shank **246***a* and tightened to the first outer plate **150** for coupling the torque transfer tube **66** to the arm assembly **302**. In addition, the adhesive may be applied to the surface **244***a* of the third block **244** to aid in coupling the third block **244** to the inner tube **112** of the second beam **312**. Further, the adhesive may be applied about the second surface **244***b* or the perimeter of the third block **244** to aid in coupling the third block **244** to the first tube end **240** of the torque transfer tube **66**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the first tube end **240** to the second block **158**.

With reference back to FIG. **23**, the first beams **310**, the second beams **312**, the vehicle mounting assemblies **314**, the bucket mount bracket subassemblies **316**, **318**, the knee mounting subassemblies **320**, the torque transfer tube **66** the adhesive, the mechanical fasteners **227** and the flange nuts **229** comprise a kit **380** for the HLBAA **300**. In one example, in order to assemble the arm assembly **302** and the second arm assembly **304**, with the inner tubes **112** formed, in one example, the inner tubes **112** are coated with the adhesive, and the inner tubes **112** are positioned within the respective outer tubes **322** to couple the respective inner tubes **112** to the outer tubes **322** (FIG. **21**). With the angled blocks **202** formed, with reference to FIG. **32**, the angled blocks **202** are inserted into a second end **112***c* of a respective one of the inner tubes **112** associated with the first beam **310** and a first end **112***d* of a respective one of the inner tubes **112** associated with the second beam **312** to couple two of the inner tubes **112** together, as also shown in FIG. **35**. This is repeated to form two subassemblies, one for each of the arm assembly **302** and the second arm assembly **304**. The adhesive may be applied to the angled blocks **202** and used to couple the angled blocks **202** to the inner tubes **112**.

With reference to FIG. **28**, with the retaining flanges **182** formed with the base **180**, the bushing **184** is inserted through the bores **186** and coupled to the retaining flanges **182**, via welding, for example. With the retaining flange **156** formed, the retaining flange **156** is coupled to the base **180**, via welding, for example. With the second block **158** formed, the retaining flange **156** is coupled to the second block **158**. Generally, with a layer of the adhesive applied to the slots **198** and the surface **158***a* of the second block **158**, the first leg **190** and the second leg **192** are coupled to the slots **198** such that the first surface **194***a* contacts the surface **158***a* of the second block **158**. The second block **158** is inserted into a second end **112***e* of the inner tube **112** associated with one of the second beams **312**. In one example, the adhesive is applied about the second block **158** to further couple the second block **158** to the inner tube **112**. This process is repeated to couple another one of the second blocks **158** to the inner tube **112** associated with the other of the second beams **312**.

With reference to FIG. **25**, with the blocks **134** formed, one of the blocks **134** is inserted into a first end **112***f* of the inner tube **112** associated with one of the first beams **100**, and the other of the blocks **134** is inserted into a first end **112***f* of the inner tube **112** associated with the other of the first beams **310**. The blocks **134** may be coupled to the inner tubes **112** via the adhesive, which may surround the blocks **134** to fixedly retain the blocks **134** within the inner tubes **112**. One of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the inner tube **112** associated with the first beam **310** of the arm assembly **302**, and the other of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the inner tube **112** associated with the first beam **310** of the second arm assembly **304**.

With reference to FIG. **32**, with the first pair of reinforcing plates **360** formed, the first pair of reinforcing plates **360** is coupled about each of the first beams **310**, via the adhesive, for example. With the second pair of reinforcing plates **362** formed, the second pair of reinforcing plates **362** are coupled about each of the second beams **312**, via the adhesive, for example. The knee plates **200** are coupled to the reinforcing plates **360**, **362**, via welding, for example. With reference to FIG. **28**, with the first reinforcing plate **340** and the second reinforcing plate **342** formed, the first reinforcing plate **340** and the second reinforcing plate **342** are coupled about the second beams **312**, via the adhesive, for example. The first outer plates **150** are coupled to the second reinforcing plates **342** and the second inner plates **152** are coupled to the first reinforcing plates **340**, via welding, for example. With reference to FIG. **25**, with the reinforcing plates **330** formed, the reinforcing plates **330** are coupled about the first beams **310**, via the adhesive, for example. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the arm assembly **302**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **310** of the arm assembly **302**. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the second arm assembly **304**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **310** of the second arm assembly **304**.

With reference to FIG. **32**, the mechanical fasteners **227** are inserted through the first plate bores **214** of each pair of knee plates **200**, the first block bore **226** of the angled block **202** and the central plate bore **370** of the first pair of reinforcing plates **360**. The mechanical fasteners **227** are secured with the flange nut **229**, for example. The mechanical fasteners **227** are inserted through the second plate bores **216** of each pair of knee plates **200**, the second block bore **228** of the angled block **202** and the central plate bore **376** of the second pair of reinforcing plates **362**. The mechanical fasteners **227** are secured with the flange nut **229** to reinforce the connection of the knee plates **200** to the respective first beam **310** and the second beam **312**. The coupling pins **204** are inserted through the first pin bore **218** and the second pin bore **220**, respectively, and the collars **230** are coupled about the opposed ends of the coupling pins **204**. Pins are inserted through the bores **204***a* of the coupling pins **204** and the cross-bores **232***b* of the collars **230** to couple the coupling pins **204** to the respective pair of knee plates **200**.

With reference to FIGS. **33** and **34**, with the torque transfer tube **66** formed, the adhesive is applied to the surface **244***a* and the second surface **244***b* of the third block **244** and the third block **244** is inserted into the first tube end **240**. This process is repeated to couple another one of the third blocks **244** to the second tube end **242**. With the third block **244** coupled to the first tube end **240**, the first tube end **240** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **312** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the first tube end **140** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the first tube end **240** to the arm assembly **302**. With reference to FIG. **16**, the second tube end **242** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **312** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the second tube end **242** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the second tube end **242** to the arm assembly **302**.

With the HLBAA **300** assembled, the first end **310***a* of the first beams **310** of the HLBAA **300** may be coupled to the loader **10** (FIG. **1**) or the compact utility tractor **1000** (FIG. **1**A) via the pin **252** (FIG. **2**) engaging the sleeves **132** of the respective vehicle mounting assemblies **314**. The fourth end **312***b* of the second beams **312** of the HLBAA **300** may be coupled to the couplers **74**, **76** for coupling the bucket **52** (FIG. **1** or FIG. **1**A) to the HLBAA **300** by engaging the coupling pins **80** (FIG. **2**) with each of the bushings **184** of each of the bucket mount bracket subassemblies **316**, **318** and the couplers **74**, **76**. The hydraulic cylinders **34**, **36**, **38** may also be coupled to the coupling pins **204** of the arm assembly **302** and the second arm assembly **304**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to FIGS. **36-40**, a HLBAA **400** is shown. As the HLBAA **400** includes components that are substantially similar to or the same as the HLBAA **50** discussed with regard to FIGS. **1-19** and the HLBAA **300** discussed with regard to FIGS. **20-35**, the same reference numerals will be used to denote the same or similar features. The HLBAA **400** may couple the bucket **52** to the loader **10**, or may couple the bucket **52** to the compact utility tractor **1000**. It should be noted that the HLBAA **400** may also be used with a variety of other work vehicles. In this example, with reference to FIGS. **36** and **37**, the HLBAA **400** includes an arm assembly **402**, a second arm assembly **404** and the hollow torque transfer tube **66** that interconnects the arm assembly **402** and the second arm assembly **404**. Each of the arm assembly **402** and the second arm assembly **404** include a first beam **410**, a second beam **412**, the vehicle mounting subassembly **314**, the respective bucket mount bracket or bucket mount bracket subassembly **316**, **318** and the knee mounting subassembly **320**. Generally, the arm assembly **402** is a mirror image of the second arm assembly **404**.

The first beam **410** and the second beam **412** are each formed from the lightweight material. In one example, with reference to FIG. **38**, the first beam **410** and the second beam **412** are each composed of the outer tube **322**. As the first beam **410** and the second beam **412** have the same composition, the composition of the first beam **410** is illustrated in FIG. **38** with the understanding that the composition of the second beam **412** is the same. As discussed, the outer tube **322** is composed of a polymer-based resin that includes reinforcing fibers and/or reinforcing particles. The reinforcing fibers, include, but are not limited to, glass, basalt, carbon, aramids, olefins, and/or cellulose. The polymer-based resin may be a thermoset or a thermoplastic. In the example of a thermoset polymer-based resin, the polymer-based resin includes, but is not limited to, polyurethane, epoxy, and acrylic. In the example of a thermoplastic polymer-based resin, the polymer-based resin includes, but is not limited to, polyamides, polyolefins, polycarbonates, or polyesters. The outer tube **322** is formed using wet-ply lay-up, pultrusion, hand lay-up, filament winding, extrusion, injection molding, rotomolding, blow molding, etc.

With reference to FIG. **37**, the first beam **410** includes a first end **410***a* and an opposite second end **410***b*. The first end **410***a* defines a respective first end of the arm assembly **402** and the second arm assembly **404**. The first beam **410** defines the first through bore **122** at the first end **410***a*, and defines the second through bore **124** at the second end **410***b*. The first through bore **122** receives a portion of the vehicle mounting subassembly **414** to couple the vehicle mounting subassembly **414** to the first beam **410**. The second through bore **124** is coupled to the knee mounting subassembly **320**. In one example, the second end **410***b* of the first beam **410** is beveled. By beveling the second end **410***b*, the second end **410***b* of the first beam **410** may be positioned against a cooperating bevel defined on a third end **412***a* of the second beam **412** so that the second beam **412** extends at an angle relative to the first beam **410**.

The second beam **412** includes the third end **412***a* and an opposite fourth end **412***b*. The fourth end **412***b* defines a respective second end of the arm assembly **402** and the second arm assembly **404**. In one example, the third end **412***a* of the second beam **412** is beveled. By beveling the third end **412***a*, the second beam **412** extends at an angle relative to the first beam **410** to assist in coupling the bucket **52** (FIG. **1**) to the HLBAA **400**. The second beam **412** defines the third through bore **126** at the third end **412***a*, and defines the fourth bore **128** and the fifth bore **129** at the fourth end **412***b*. The third through bore **126** is coupled to the knee mounting subassembly **320**. The fourth bore **128** and the fifth bore **129** each receives a portion of the bucket mount bracket subassembly **316**, **318** and the torque transfer tube **66** to couple the bucket mount bracket subassembly **316**, **318** and the torque transfer tube **66** to the second beam **412**.

The vehicle mounting subassembly **314** is coupled to the first end **410***a* of each first beam **410** of the arm assembly **402** and the second arm assembly **404** and is configured to couple the arm assembly **402** and the second arm assembly **404** to the loader **10**. With reference to FIG. **39**, in one example, the vehicle mounting subassembly **314** includes the pair of lock plates **130**, the sleeve **132**, the block **134** and the pair of reinforcing plates **330**. The pair of lock plates **130** is generally coupled to the first beam **310** so as contact a respective one of the pair of reinforcing plates **330**. The sleeve **132** is received through the first through bore **122** and the block **134**, and the plurality of threads **140***a*, **140***b* matingly engage with the plurality of threads **136***a* of a respective one of the pair of lock plates **130** to couple the vehicle mounting subassembly **314** to the first beam **310**. The sleeve **132** enables the pin **252** (FIG. **2**) to pass through the vehicle mounting subassembly **314** the couple the respective one of the arm assembly **402** and the second arm assembly **404** to the loader **10** (FIG. **1**). The block **134** is sized to be received wholly within the outer tube **322** at the first end **410***a* of the first beam **410**. The block **134** may be coupled to the outer tube **322** via the adhesive, which may surround the block **134** to fixedly retain the block **134** within the outer tube **322**. The pair of reinforcing plates **330** is coupled about the outer tube **322** at the first end **410***a* of the first beam **310** to define an exterior surface of the first beam **410** at the first end **410***a*. Each of the reinforcing plates **330** are coupled to the outer tube **322** by the adhesive.

With reference back to FIG. **37**, the bucket mount bracket subassembly **316**, **318** couples the bucket **52** (FIG. **1**) to the HLBAA **400**. As the bucket mount bracket subassembly **316** is a mirror image of the bucket mount bracket subassembly **318**, for ease of description, the bucket mount bracket subassembly **316** will be discussed herein with the understanding that the bucket mount bracket subassembly **318** is substantially the same. The bucket mount bracket subassembly **316** includes the first outer plate **150**, the second inner plate **152**, the flange assembly **154**, the retaining flange **156** (FIG. **40**), the second block **158** (FIG. **40**), the first reinforcing plate **340** and the second reinforcing plate **342**.

The flange assembly **154** cooperates with the first outer plate **150** and the second inner plate **152** for coupling the bucket **52** (FIG. **1**) to the arm assembly **402**. The second block **158** is received wholly within the outer tube **322** at the fourth end **412***b* of the second beam **412**. The second block **158** is received within the outer tube **322** such that the fourth bore **128** and the fifth bore **129** of the second beam **412** are coaxially aligned with the second cross-bore **196** of the second block **158**. In addition, the second block **158** may be coupled to the outer tube **322** via the adhesive, which may surround the second block **158** to fixedly retain the second block **158** within the outer tube **322**. The bucket mount bracket subassembly **316** is coupled to the second beam **412** such that the second block **158** is received wholly within the outer tube **322** of the second beam **412**, and the flange assembly **154** is disposed external to the second beam **412** (FIG. **40**). The first leg **190** and the second leg **192** are coupled to the slots **198**, and the retaining base **194** is coupled to the base **180** of the flange assembly **154**. The first reinforcing plate **340** and the second reinforcing plate **342** are coupled about the outer tube **322** at the fourth end **412***b* of the second beam **412**, via the adhesive, for example, to define an exterior surface of the second beam **412** at the fourth end **412***b*. The first reinforcing plate **340** and the second reinforcing plate **342** cooperate to enclose the outer tube **322** at the fourth end **412***b*.

The knee mounting subassembly **320** interconnects the first beam **410** with the second beam **412**. The knee mounting subassembly **320** includes the pair of knee plates **200**, the angled block **202** (FIG. **40**), the pair of coupling pins **204**, the first pair of reinforcing plates **360** and the second pair of reinforcing plates **362**. The angled block **202** is received wholly within a portion of the outer tube **322** of the first beam **410** and a portion of the outer tube **322** of the second beam **412** when the arm assembly **402** is assembled. The first pair of reinforcing plates **360** is coupled about the outer tube **322** at the second end **410***b* of the first beam **410** to define an exterior surface of the first beam **410** at the second end **410***b*. The second pair of reinforcing plates **362** is coupled about the outer tube **322** at the third end **412***a* of the second beam **412**, via the adhesive, for example, to define an exterior surface of the second beam **412** at the third end **412***a*.

The torque transfer tube **66** interconnects the arm assembly **402** and the second arm assembly **404**. The torque transfer tube **66** is coupled to each of the arm assembly **402** and the second arm assembly **404** at the fourth end **412***b* of the respective second beam **412**. In this example, the adhesive may be applied to the surface **244***a* of the third block **244** to aid in coupling the third block **244** to the outer tube **322** of the second beam **412** (FIG. **40**). In one example, the adhesive is also applied about the second cross-bore **196** of the second blocks **158** to further couple the first tube end **240** and the second tube end **242** to the respective second block **158**.

The first beams **410**, the second beams **412**, the vehicle mounting assemblies **314**, the bucket mount bracket subassemblies **316**, **318**, the knee mounting subassemblies **320**, the torque transfer tube **66**, the adhesive, the mechanical fasteners **227** and the flange nuts **229** comprise a kit **450** for the HLBAA **400**. In one example, in order to assemble the arm assembly **402** and the second arm assembly **404**, with the outer tubes **322** formed and the angled blocks **202** formed, with reference to FIG. **40**, the angled blocks **202** are inserted into the second end **410***b* of a respective one of the outer tubes **322** associated with the first beam **410** and the third end **412***a* of a respective one of the outer tubes **322** associated with the second beam **412** to couple two of the outer tubes **322** together. This is repeated to form two subassemblies, one for each of the arm assembly **402** and the second arm assembly **404**. The adhesive may be applied to the angled blocks **202** and used to couple the angled blocks **202** to the outer tubes **322** of the first beam **410** and the second beam **412**.

With reference to FIGS. **37** and **40**, with the retaining flanges **182** formed with the base **180**, the bushing **184** is inserted through the bores **186** and coupled to the retaining flanges **182**, via welding, for example. With the retaining flange **156** formed, the retaining flange **156** is coupled to the base **180**, via welding, for example. With the second block **158** formed, the retaining flange **156** is coupled to the second block **158** (FIG. **34**). Generally, with a layer of the adhesive applied to the slots **198** and the surface **158***a* of the second block **158**, the first leg **190** and the second leg **192** are coupled to the slots **198** such that the first surface **194***a* contacts the surface **158***a* of the second block **158**. The second block **158** is inserted into the fourth end **412***b* of one the second beams **412**. In one example, the adhesive is applied about the second block **158** to further couple the second block **158** to the outer tube **322**. This process is repeated to couple another one of the second blocks **158** to the outer tube **322** associated with the other of the second beams **312**.

With reference to FIGS. **37** and **40**, with the blocks **134** formed, one of the blocks **134** is inserted into the first end **410***a* of one of the first beams **410**, and the other of the blocks **134** is inserted into the first end **410***a* of the other of the first beams **410**. The blocks **134** may be coupled to the outer tube **322** via the adhesive, which may surround the blocks **134** to fixedly retain the blocks **134** within the outer tube **322**. One of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the first beam **410** of the arm assembly **402**, and the other of the sleeves **132** is inserted through the first through bore **122** and the cross-bore **142** of the block **134** coupled to the first beam **410** of the second arm assembly **404**.

With reference to FIGS. **37** and **40**, with the first pair of reinforcing plates **360** formed, the first pair of reinforcing plates **360** is coupled about each of the first beams **410**, via the adhesive, for example. With the second pair of reinforcing plates **362** formed, the second pair of reinforcing plates **362** are coupled about each of the second beams **412**, via the adhesive, for example. The knee plates **200** are coupled to the reinforcing plates **360**, **362**, via welding, for example. With reference to FIG. **28**, with the first reinforcing plate **340** and the second reinforcing plate **342** formed, the first reinforcing plate **340** and the second reinforcing plate **342** are coupled about the second beams **412**, via the adhesive, for example. The first outer plates **150** are coupled to the second reinforcing plates **342** and the second inner plates **152** are coupled to the first reinforcing plates **340**, via welding, for example. With the reinforcing plates **330** formed, the reinforcing plates **330** are coupled about the first beams **410**, via the adhesive, for example. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the arm assembly **402**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **410** of the arm assembly **402**. One of the pair of lock plates **130** is coupled to the first end **132***a* of the sleeve **132** of the second arm assembly **404**, and the other one of the lock plates **130** is coupled to the second end **132***b* to couple the sleeve **132** to the first beam **410** of the second arm assembly **404**.

With reference to FIG. **37**, the mechanical fasteners **227** are inserted through the first plate bores **214** of each pair of knee plates **200** (FIG. **32**), the first block bore **226** of the angled block **202** and the central plate bore **370** of the first pair of reinforcing plates **360**. The mechanical fasteners **227** are secured with the flange nut **229**, for example. The mechanical fasteners **227** are inserted through the second plate bores **216** of each pair of knee plates **200**, the second block bore **228** of the angled block **202** and the central plate bore **376** of the second pair of reinforcing plates **362**. The mechanical fasteners **227** are secured with the flange nut **229** to reinforce the connection of the knee plates **200** to the respective first beam **410** and the second beam **412**. The coupling pins **204** are inserted through the first pin bore **218** and the second pin bore **220**, respectively, and the collars **230** are coupled about the opposed ends of the coupling pins **204**. Pins are inserted through the bores **204***a* of the coupling pins **204** and the cross-bores **232***b* of the collars **230** to couple the coupling pins **204** to the respective pair of knee plates **200**.

With reference to FIGS. **37** and **40**, with the torque transfer tube **66** formed, the adhesive is applied to the surface **244***a* and the second surface **244***b* of the third block **244** and the third block **244** is inserted into the first tube end **240**. This process is repeated to couple another one of the third blocks **244** to the second tube end **242**. With the third block **244** coupled to the first tube end **240**, the first tube end **240** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **412** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the first tube end **140** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the first tube end **240** to the arm assembly **62**. The second tube end **242** is positioned within the second cross-bore **196** of the second block **158** such that the shank **246***a* extends through the fourth bore **128** of the second beam **412** and the first plate bore **164** of the first outer plate **150**. In one example, the adhesive is applied about the second cross-bore **196** to further couple the second tube end **242** to the second block **158**. The flange nut **248** is coupled to the shank **246***a* to couple the second tube end **242** to the arm assembly **402**.

With the HLBAA **400** assembled, the first end **410***a* of the first beams **410** of the HLBAA **400** may be coupled to the loader **10** (FIG. **1**) or the compact utility tractor **1000** (FIG. **1**A) via the pin **252** (FIG. **2**) engaging the sleeves **132** of the respective vehicle mounting assemblies **314**. The fourth end **412***b* of the second beams **412** of the HLBAA **400** may be coupled to the couplers **74**, **76** for coupling the bucket **52** (FIG. **1** or FIG. **1**A) to the HLBAA **400** by engaging the coupling pins **80** (FIG. **2**) with each of the bushings **184** of each of the bucket mount bracket subassemblies **316**, **318** and the couplers **74**, **76**. The hydraulic cylinders **34**, **36**, **38** may also be coupled to the coupling pins **204** of the arm assembly **402** and the second arm assembly **404**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19**, the HLBAA **300** described with regard to FIGS. **20-35** and the HLBAA **400** described with regards to FIGS. **36-40** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to FIGS. **41** and **42**, one or more of the blocks **134**, **158**, **202** may be configured differently to assist in coupling the respective one of the blocks **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. For example, each of the blocks **134**, **158**, **202** may include at least one or a plurality of ribs **460**. The ribs **460** may be formed integrally with or are monolithic with the respective block **134**, **158**, **202**. In the example of FIGS. **41** and **42**, an example block **134'** is shown with four integral ribs **460**. The ribs **460** are defined or formed integrally with the block **134'** on each of the four sides **462***a*-**462***d* of the block **134'**. Each of the ribs **460** extend a distance beyond the respective side **462***a*-**462***d* of the block **134'** to assist in positioning the block **134'** within the respective first beam **100**, **310**, **410**. It should be noted that while the ribs **460** are illustrated as rectangular, the ribs **460** may have any desired shape that extends a distance above the respective side **462***a*-**462***d* to aid in the insertion of the block **134'** into the respective first beam **100**, **310**, **410**. It should also be understood that the third block **244** may also include one or more of the ribs **460** to aid in the insertion of the third block **244** into the torque transfer tube **66**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19**, the HLBAA **300** described with regard to FIGS. **20-35** and the HLBAA **400** described with regards to FIGS. **36-40** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to FIGS. **43** and **44**, one or more of the blocks **134**, **158**, **202** may be configured differently to assist in coupling the respective one of the blocks **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. For example, each of the blocks **134**, **158**, **202** may include at least one insert or foam block **470**. In the example of FIGS. **43** and **44**, the block **134** is shown. It should be noted that the foam block **470** may be employed with the second block **158** and the angled block **202**. Moreover, the foam block **470** may be employed with the third block **244** to couple the third block **244** to the torque transfer tube **66**.

The foam block **470** may be discrete from the respective block **134**, **158**, **202**, and may be composed of a suitable medium-density foam. In one example, the foam block **470** is composed of polyurethane, and is insert molded. Alternatively, the foam block **470** may be molded into the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412** during the formation of the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. The foam block **470** has a cross-section that corresponds to a cross-section of the respective one of the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412** such that the foam block **470** may be positioned within the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. With reference to FIG. **44**, the foam block **470** is generally inserted into the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412** prior to the insertion of the respective block **134**, **158**, **202** to serve as a dam to prevent the further advancement of the adhesive **472** within the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. Stated another way, the foam block **470** blocks the flow of the adhesive **472** through the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**, which results in the adhesive **472** encapsulating and bonding the respective one of the blocks **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. In the example of the third block **244**, the foam block **470** may have a circular cross-section to block the flow of the adhesive **472** through the torque transfer tube **66**, which results in the adhesive **472** encapsulating and bonding the third blocks **244** to the torque transfer tube **66**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19**, the HLBAA **300** described with regard to FIGS. **20-35** and the HLBAA **400** described with regards to FIGS. **36-40** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to FIGS. **45** and **46**, one or more of the blocks **134**, **158**, **202** may be configured differently to assist in coupling the respective one of the blocks **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. For example, each of the blocks **134**, **158**, **202** may include at least one energy activated foam block **480**. In the example of FIGS. **45** and **45**, the block **134** is shown. It should be noted that the energy activated foam block **480** may be employed with the second block **158** and the angled block **202**. Moreover, the energy activated foam block **480** may be employed with the third block **244** to couple the third block **244** to the torque transfer tube **66**.

The energy activated foam block **480** may be composed of an energy activated foam, including, but not limited to, expandable epoxy products commercially available from Sika Automotive AG, such as SIKAREINFORCER®, which may be co-molded with the respective block **134**, **158**, **202**, **244**. In this example, the energy activated foam block **480** may be activated by an external source to cause the energy activated foam block **480** to expand into a foam layer **480'** that encapsulates and secures the respective block **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412** as shown in FIG. **46**. In the example of the third block **244**, the energy activated foam block **480** may be activated by an external source to cause the energy activated foam block **480** to expand into the foam layer **480'** and encapsulate and secure the third block **244** to the torque transfer tube **66**.

It should be noted that the HLBAA **50** described with regard to FIGS. **1-19**, the HLBAA **300** described with regard to FIGS. **20-35** and the HLBAA **400** described with regards to FIGS. **36-40** may be configured differently to couple a work implement, such as the bucket **52**, to a work vehicle, such as the loader **10**. In one example, with reference to FIG. **47**, one or more of the blocks **134**, **158**, **202** and the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412** may be configured differently to assist in coupling the respective one of the blocks **134**, **158**, **202** to the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. For example, each of the blocks **134**, **158**, **202** may be formed with a circular cross-section, which may be received within a corresponding circular cross-section defined in the respective one of the first beams **100**, **310**, **410** and/or second beams **102**, **312**, **412**. In the example of FIG. **47**, a first beam **410'** is shown with a hexagonal cross-section **490**, which defines an internal cylindrical bore **492**. The hexagonal cross-section **490** of first beam **410'** is integrally formed with the first beam **410'**, via pultrusion, for example. A block **134'** is formed with a circular cross-section **494**, and is sized to be received within the cylindrical bore **492**. The circular cross-section **494** of block **134'** is formed, via pultrusion, for example. Alternatively, the block **134'** may comprise a tube having a thickened wall, which is formed from G10 material via pultrusion, for example. By forming the block **134'** with the circular cross-section, the adhesive **496** may be disposed about the perimeter of the block **134'**, and the block **134'** may be inserted and bonded to the first beam **410'** by inserting the block **134'** and twisting the block **134'** within the first beam **410'**, which may reduce assembly time.

Also, the following examples are provided, which are numbered for easier reference:

1. A hybrid loader boom arm assembly kit for a loader work vehicle, the kit comprising: a hollow first beam formed from a lightweight material; a block formed from a second lightweight material, the block configured to couple within the first beam; at least one first steel reinforcing plate configured to couple to the first beam at the end; and at least one connecting plate configured to couple to the at least one first reinforcing plate.

2. The kit of example 1, further comprising a second block formed from the second lightweight material, the second block defining a cross-bore and configured to be coupled to the first beam.

3. The kit of example 2, further comprising a sleeve configured to be coupled to the cross-bore.

4. The kit of example 3, further comprising a pair of lock plates configured to retain the sleeve within the cross-bore.

5. The kit of example 4, further comprising at least one second steel reinforcing plate configured to be coupled to the first beam.

6. The kit of example 1, further comprising: a hollow second beam formed from the lightweight material; at least one third steel reinforcing plate configured to couple to the second beam; and a third block formed from the second lightweight material that defines a pair of opposed slots and a third bore, the third block configured to be coupled to the second beam.

7. The kit of example 6, further comprising a bucket mount bracket configured to be coupled to the third block.

8. The kit of example 7, further comprising a hollow torque transfer tube, the torque transfer tube having a first tube end configured to be coupled to the third block.

9. The kit of example 8, further comprising a second arm assembly that includes a second third block, and the torque transfer tube is configured to be coupled to the second third block.

10. A method of assembling a hybrid loader boom arm for a loader work vehicle, the method comprising: coupling a first beam formed from a lightweight material to a first block formed from a second lightweight material; coupling at least one first steel reinforcing plate to the first beam at an end of the first beam; and coupling at least one connecting plate to the at least one first reinforcing plate.

11. The method of example 10, further comprising: coupling a second block formed from the second lightweight material within a third end of the first beam, the third end opposite the first end.

12. The method of example 11, further comprising: coupling a sleeve to a cross-bore defined in the second block, the sleeve configured to couple to the loader work vehicle.

13. The method of example 12, further comprising: coupling a pair of lock plates to opposed ends of the sleeve to retain the sleeve within the cross-bore at the third end of the first beam.

14. The method of example 13, further comprising: coupling at least one second steel reinforcing plate to the third end of the first beam such that at least one of the pair of lock plates is adjacent to the at least one second steel reinforcing plate.

15. The method of example 10, further comprising: coupling the first block within a second beam formed from the lightweight material to form an arm assembly; coupling at least one third steel reinforcing plate to the second beam at a second end of the second beam; coupling a third block formed from the second lightweight material within a fourth end of the second beam, the fourth end opposite the second end; coupling a bucket mount bracket to a pair of opposed slots defined in the third block; coupling a first tube end of a hollow torque tube to the third block of the arm assembly; and coupling a second tube end of the torque tube to a second third block disposed within an fifth end of a second arm assembly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. Explicitly referenced embodiments herein were chosen and described to best explain the principles of the disclosure and their practical application, and to enable others of ordinary skill in the art to understand the disclosure and recognize many alternatives, modifications, and variations on the described example(s). Accordingly, various embodiments and implementations other than those explicitly described are within the scope of the following claims.

What is claimed is:

1. A hybrid loader boom arm assembly kit for a loader work vehicle, the kit comprising:
- a hollow first beam formed from a first material having a lower density than steel, the first beam comprising a first end and a second end, and comprising a first through bore disposed proximate the first end;
- a block formed from a second material having a lower density than steel, the block comprising a through bore, and the through bore portion of the block is configured to be operably disposed inside the first beam aligning the block bore with the first beam first through bore;
- at least one first steel reinforcing plate configured to couple to the first beam; and
- at least one connecting plate configured to couple to the at least one first reinforcing plate.

2. The kit of claim **1**, further comprising an angled block formed from the second material, the second block defining a cross-bore and configured to be coupled to the first beam at the second end.

3. The kit of claim **2**, further comprising a sleeve configured to be coupled to the cross-bore.

4. The kit of claim **3**, further comprising a pair of lock plates configured to retain the sleeve within the cross-bore.

5. The kit of claim **4**, further comprising at least one second steel reinforcing plate configured to be coupled to the first beam.

6. The kit of claim **1**, further comprising:
- a hollow second beam formed from the first material;
- at least one third steel reinforcing plate configured to couple to the second beam; and
- a second block formed from the second material that defines a pair of opposed slots and a third bore, the second block configured to be coupled to the second beam at a fourth end.

7. The kit of claim **6**, further comprising a bucket mount bracket configured to be coupled to the second block.

8. The kit of claim **7**, further comprising a hollow torque transfer tube, the torque transfer tube having a first tube end configured to be coupled to the second block.

9. The kit of claim **8**, further comprising a second arm assembly that includes a third block, and the torque transfer tube is configured to be coupled to the third block.

10. A method of assembling a hybrid loader boom arm for a loader work vehicle, the method comprising:

coupling a first beam formed from a first material having a lower density than steel to a first block formed from a second material having a lower density than steel, wherein the first beam comprises a first end and a second end, and comprises a first through bore disposed proximate the first end, and wherein the first block comprises a through bore, and the through bore portion of the block is configured to be operably disposed inside the first beam aligning the block bore with the first beam first through bore;

coupling at least one first steel reinforcing plate to the first beam at a first end; and

coupling at least one connecting plate to the at least one first reinforcing plate.

11. The method of claim **10**, further comprising:

coupling an angled block formed from the second material within the second end of the first beam, the second end opposite the first end.

12. The method of claim **11**, further comprising:

coupling the angled block within a third end of a second beam formed from the first material to form an arm assembly;

coupling at least one third steel reinforcing plate to the second beam at the third end of the second beam; and

coupling a second block formed from the second material within a fourth end of the second beam, the fourth end opposite the third end.

13. The method of claim **12**, further comprising:

coupling a bucket mount bracket to a pair of opposed slots defined in the second block.

14. The method of claim **12**, further comprising:

coupling a first tube end of a hollow torque tube to the second block of the arm assembly; and

coupling a second tube end of the torque tube to a third block disposed within a fifth end of a second arm assembly.

15. The method of claim **10**, further comprising:

coupling a sleeve to a cross-bore defined in the first block, the sleeve configured to couple to the loader work vehicle.

16. The method of claim **15**, further comprising:

coupling a pair of lock plates to opposed ends of the sleeve to retain the sleeve within the cross-bore at the first end of the first beam.

17. The method of claim **16**, further comprising:

coupling at least one second steel reinforcing plate to the first end of the first beam such that at least one of the pair of lock plates is adjacent to the at least one second steel reinforcing plate.

18. A method of assembling a hybrid loader boom arm for a loader work vehicle, the method comprising:

coupling a first beam formed from a first material having a lower density than steel to a second beam formed from the first material using an angled block formed from a second material having a lower density than steel to form an arm assembly, the first beam comprising a second through bore disposed at a second end, the second beam comprising a third through bore disposed at a third end, the angled block comprising a first through bore at a first block end and a second through bore at a second block end, the first block bore configured to be operably disposed inside the second end of the first beam aligning the first block bore with the first beam second through bore, and the second block bore configured to be operably disposed inside the third end of the second beam aligning the second block bore with the second beam third through bore;

coupling at least one first steel reinforcing plate to the first beam at the second end of the first beam;

coupling at least one second steel reinforcing plate to the second beam at the third end of the second beam; and

coupling at least one connecting plate to the at least one first reinforcing plate and the at least one second reinforcing plate.

19. The method of claim **18**, further comprising:

coupling a first block formed from the second material within a first end of the first beam, the second end opposite the first end;

coupling a sleeve to a cross-bore defined in the first block, the sleeve configured to couple the arm assembly to the loader work vehicle; and

coupling a pair of lock plates to opposed ends of the sleeve to retain the sleeve within the cross-bore at the first end of the first beam.

20. The method of claim **18**, further comprising:

coupling a second block formed from the second material within a fourth end of the second beam, the fourth end opposite the third end;

coupling a bucket mount bracket to a pair of opposed slots defined in the second block; coupling a first tube end of a hollow torque tube to the second block of the arm assembly; and

coupling a second tube end of the torque tube to a third block disposed within a fifth end of a second arm assembly.

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